

The background of the cover is a photograph of the Statue of Liberty in New York City. The statue is silhouetted against a bright, golden sunset sky. The water of the harbor is visible at the bottom of the image.

Project New America

McKINLEY CONWAY

**A proposal that exploits hidden strengths to
lift the country out of economic doldrums,
achieve energy independence and
set the stage for a
golden age of leadership.**

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Project New America

A proposal that exploits hidden strengths to lift the country out of economic doldrums, achieve energy independence and set the stage for a golden age of leadership.

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Acknowledgements

Somewhere in the text that follows I have made it plain that this book contains ideas from many sources. To attempt to name them all would require hundreds of pages and burden the reader unnecessarily. However, I would like to mention a few people who have contributed in special ways.

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McKinley Conway
December 2008

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1. Introduction

Our nation is now at a crossroads. Without further delay we must decide whether to fall back and accept “has been” status or to undertake a bold new strategy to reassert our leadership.

Some will say that we have gotten ourselves into such a hole that we can never get out. If these pessimists had studied our history they would know that our nation has faced many stressful challenges and responded with some of our greatest achievements.

During the great depression in the 1930s we launched the TVA program to build hydro-electric plants along the Tennessee River in the poverty-stricken South. That started a strong recovery cycle.

During the 1940s when Hitler stormed through Europe and the Japanese took over the Pacific, we set up the Manhattan Project at Oak Ridge, Tenn., and developed the atomic bomb, a super weapon that brought the war to a successful close.

In the 1960s, fearing that the U.S.S.R. was gaining a worldwide edge in space exploration, we undertook to put a man on the moon within 10 years. We succeeded and took a leading position in space.

Today we need to define a new national project and commit ourselves to it. That is the objective of this report.

This plan is not presented as an original invention of the author. Overall, it is a distillation of ideas from many sources. Among these sources are releases from private firms, reports from development agencies, and information from scores of Web sites. We are grateful to all whose work is involved.

2. A Proposal: Project New America

Jobs! Energy!

Specifically, this plan has two objectives:

1. To create one million new jobs per year beginning in 2009 – *ten million new jobs* by 2020. This will rejuvenate the American economy and make us competitive around the world.
2. To achieve *energy independence* by 2020. This will greatly enhance our global diplomatic and defense posture while producing many economic and environmental benefits at home.

Schedule, Stages

No matter what politicians may have said, our nation's problems can't be solved via any quick and easy programs. This is a ten-year undertaking that will require dedication and commitment every day. Throughout the decade, strong and shrewd management will be essential.

● 2009 – The first year

This is not a job for politicians who would treat it as a huge pork barrel. We must select, organize, and empower a project management team of top professionals experienced in managing very large ventures with numerous components. During this start-up period the aim must be to get a number of key projects going without long bureaucratic delays.

Every entity involved must feel a great sense of urgency.

Every project has its opponents. Some critics are skilled in delaying projects for years. The trial at this stage will be to allow reasonable debate for a reasonable time but then to proceed with reasonable projects despite opposition. Intelligent compromise must rule.

Contracts should be let for scores of huge wind, solar and other alternative energy projects. A plan should be drawn for a new national power grid – an “interstate highway for electricity.” Construction should begin on the natural gas line from Alaska to Wyoming. Oil drilling projects at offshore sites should be launched.

The magnitude of these programs should be such that one million new jobs are created directly and indirectly by the end of the first year, 2010.

While the management team is busy launching projects, public officials should focus on conservation measures. For example, at the federal level, Congress should set a speed limit of 55 mph (89 kmph) on the interstates. In local areas county commissions and city councils should permit golf carts, tri-cabs and mini-vehicles in urban areas. In general, we must slow down and save!

● 2010-2015 – The first five years

In this phase we must make fundamental shifts in how we use energy. This involves shifting power generating plants from using imported oil as a fuel and substituting natural gas from domestic sources. Millions of auto owners must shift to hybrid- and electricity-powered vehicles.

● 2015-2020 – The second five years

This is pay-off time. Many project elements begun earlier begin to come on line. We will still be using some fossil fuels of domestic origin, but we will be free of those imported at great expense.

● 2020 – The tenth year

Everything comes together. Once more we have a strong, healthy nation admired and respected around the world. Success!

(Note: during the preceding decade it will have been necessary to delay all but the most pressing repairs to the nation's infrastructure in order to pay for the new energy program. During 2020 to 2030, the healthy new economy will be able to fund a large program of repairs and modernization of key infrastructure elements.)

The secrets to our success

The keys to the success of Project New America are the exploitation of two little-known assets:

High-tech firms

First, the new energy industries include a host of high-tech firms growing at extraordinary rates. There are thousands of such firms, but the average citizen would be hard-pressed to name a dozen. The major contribution of this report is that we provide lists of these important industries.

We have included lists of firms active in each energy field. In these lists are several hundred companies that can change the world during the next decade – providing new sources of energy, shifting industry location patterns, creating new jobs, opening new business opportunities, solving environmental problems and enhancing the quality of life for people around the nation.

This is a mix of big, long-established firms venturing into new fields, small- and medium-sized firms off to a promising start, and new ventures that are little more than a gleam in the eye of the inventor.

Scattered among the listings are a few start-ups that will take off like rockets and make millions for their investors and serve important needs of mankind. Also included are much-publicized and heavily funded ventures that will go down in flames. At this point not even the most astute analysts can tell you for sure which firms will succeed and which will fail.

We have included these lists to show the scope and magnitude of firms that can make Project New America a wonderful success story.

Development organizations

Our second hidden asset is the local, metro, state and regional economic development agencies that are already experienced in creating new jobs. They have professional staffs, extensive research files, and important business connections. There are several thousand of these important units that are often over-looked. We have spent years compiling directories that are now on line. Go to www.sitenet.com.

These well-established agencies constitute a defense against bureaucracy. The biggest risk in Project New America is that Congress will look at it as a gigantic give-away program with elements to be handed off to political cronies. That would quickly doom it to failure. However, experienced area development

groups can bring in private firms to invest in ventures that will pay for themselves.

This is a program that should be driven by incentives of two types – *broad-based lures* that apply to all elements, and *tailored plans* adapted specifically to each program component. The majority of overall incentives would be tax-oriented. The specific incentives would be in the nature of bonuses for early completion, performance above expectation and similar measures. All should be crafted by executives with experience in handling large, complex ventures.

In summary, we now need a commitment from every American. Adopt this plan! Promote it! Help implement it however you can!

3. Wind Energy Industries

Multi-billion dollar wind turbine race spurs scramble for new production sites.

Jobs! Energy!

For area development executives in the upper Midwest and Great Plains states these are exciting days. For many, this is the first time they have had an edge in competing for new manufacturing plants planned by global investors. Today many “have-not” areas are the preferred locations for significant new units.

It’s all because of the wind that sweeps across the great open spaces from Texas north to Montana. Huge wind farms are springing up. The latest wind turbine units being installed in these farms are very large. This poses a problem for wind energy system manufacturers. Their key product may be a turbine blade 150 feet (46 m) long weighing several tons – so they can’t rely on Fed-Ex or UPS to make their deliveries. They need to be close to their markets.

Thus, we see **Fuhrlander AG**, a substantial German manufacturer of wind turbines, locating a new \$25 million plant near Butte, Mont. Wind turbines built at the plant will sell for about \$4 million each and produce up to 2.5 MW each of electricity.

Meanwhile, Denmark-based **Vestas Wind Systems**, the world’s leading manufacturer of wind turbines, has opened a 400,000-sq.-ft. plant at

Windsor, Colo., on the plains north of Denver. (Last year Vestas President Ditlev Engel was named to the World Development Hall of Fame in recognition of his leadership in the field.)

Nordic Windpower Ltd., a company that began in Sweden, has selected Pocatello, Idaho, as the site for its new manufacturing plant that will employ 160 people.

Acciona Energy, a firm based in Spain, and its subsidiary **Acciona Windpower**, is building a new \$23 million plant at West Branch, Iowa. The company also has plants in Spain and China.

Siemens Power Generation Inc. has announced plans to expand its turbine blade manufacturing operations in Fort Madison, Iowa. The \$33 million project includes two buildings and a rail yard. A total of about 500 workers will be located at the site.

Molded Fiber Glass Companies is opening a new wind turbine manufacturing plant in Aberdeen, S.D., to supply blades for GE turbines. The \$40 million facility will employ 750.

It's not a deal yet but it is known that **Suzlon Wind Energy**, one of the world's largest developers of wind turbines, is looking at a site at Pipestone, Minn., about 200 miles (322 km) southwest of St. Paul.

Wind turbine manufacturers looking for sites have also been attracted to existing facilities that can handle large blades and towers. For example:

Aerisyn LLC, a new alternative energy company, has selected Chattanooga for its first plant site. The firm will occupy the former Combustion Engineering facility that has 1,000-foot-(305-m.)-long bays and an 800-ton (726-metric-ton) crane. Wind turbine towers fabricated in the plant will be shipped via a barge dock on the Tennessee River adjoining the site.

Gamesa Wind Inc., a Spanish firm, has occupied facilities at the abandoned U.S. Steel plant in Bucks County, Penn. Gamesa is one of the world's largest makers of wind turbines.

New decision factors

These are just a few of the new location and site decisions being made by both the developers of wind farms and those who make the equipment for them. One of the important new site factors is *aerodynamics*. I find this to be a fascinating surprise. During the years I spent getting a couple of aeronautical engineering degrees at Georgia Tech, and later while working in NACA/NASA labs as an aerodynamicist, I never dreamed that the science of aerodynamics

might be a big factor in a great new global energy system.

Further, my logbook shows 7,000 hours piloting small aircraft throughout the United States, Canada, Mexico, Central and South America. Believe me, surface winds were of great interest – especially when they were gusting across a short dirt strip in Baja.

Today we have a vast amount of wind information compiled to aid pilots, information that now gives some guidance in planning wind energy projects. We know that in the United States the strongest on-shore winds are found in the Great Plains, stretching from Texas to Montana. Around the world, other on-shore areas with persistent good winds include eastern Siberia, northwest China and Argentina.

Good areas for offshore installations include the continental shelf along the East Coast of the United States and similar areas in Northern Europe and East Asia. Planners prefer locations where the water is less than 100 feet (30.4 m) deep. However, new designs may make it feasible to locate just about anywhere on the continental shelf.

At this point wind systems are gaining market share fast. New wind turbines can produce 3 MW each. A wind farm containing 500 turbines can thus produce 1,500 MW. Today the biggest PV solar plant has a capacity of about 40 MW. Big new mirror solar plants such as Stirling Energy's 4,500-acre (1,821-hectare) desert mirror farm is rated at 500 MW.

Site factors

When the focus is narrowed from the location region to the actual site of a wind farm, more precise wind data is needed. For big projects, engineers erect test towers on-site and measure wind velocity at various positions and elevations above the surface. Data is recorded for months to cover seasonal variations. An ideal site would show a steady non-turbulent wind of more than 10 mph (16 kmph) with few sudden gusts or storms.

The exact location of towers is very important. A lateral shift of a turbine by several hundred feet sometimes gives twice as much energy. Doubling the height of a turbine may give one-third more power.

Another important site factor is environmental impact or lack of it. A few wind farms like that proposed near Nantucket have stirred fierce opposition because of scenic considerations. Others in populated places have raised objections to noise, and in rare situations there have been alleged problems involving birds being hit by turning vanes.

However, most wind farms located in the Great Plains region have been well received. Each large turbine needs only about one-fourth of an acre (.1 hectare). Farmers on whose land turbines are sited may receive

several thousand dollars per year per unit without having to make any investment. That beats raising beef.

Facility design

Historians note that more than 2,000 years ago simple wind mills were used in Persia. They were common in the Roman Empire. In later times the Dutch began designing wind mills with vanes shaped like big sails to get more power for pumps draining lowlands. Over the years the trend has been toward ever-increasing sophistication. Today, large new wind turbines may be highly complicated machines.

Using data from NASA wind tunnel tests turbine designers are selecting airfoil sections found to be most efficient for low-speed flight. Huge turbine blades made of composite materials are precisely shaped for thickness and camber.

Wind turbine controls are also becoming much more sophisticated. New designs employ "ailerons" to adjust angle of attack to wind speed and maximize lift for greatest power. GE now offers a control system that continually adjusts the wind turbine's blade pitch angle for best rotational speed. Controls also shut turbines down when storms occur to prevent damage from over-speeding.

Leading Developers of Wind Energy Projects

The FPL Hollow Wind Energy Center in Texas is one of the world's largest. It has a total capacity of 735 MW – with an array of 291 GE 1.5-MW turbines and 130 Siemens 2.3-MW turbines



One of the world's leading owner-developers of wind farms is **FPL Energy**, P.O. Box 14000, Juno Beach, Fla. 33408-0420. A subsidiary of FPL Group Inc. (**Florida Power and Light**), FPL Energy has 47 wind farms in 15 states.

The Spanish electric utility **Iberdrola**, 8 Cardenal Gardoqui, 48008 Bilbao, Vizcaya, Spain, is one of the world's largest investors in wind power. The company recently acquired Britain's Scottish Power for \$23 billion; a 25 percent stake in Gamesa, the turbine manufacturer; and Energyworks Ltd., based in Landover, Md., for \$50 million.

Another major is **PPM Energy**, HQ, 1125 NW Couch Street, Suite 700, Portland, OR 97209. Key locations include Portland and Klamath Falls in Oregon; Houston, Texas; and Calgary, Alb. PPM also has plant operations in various states and provinces, as well as smaller office locations.

Also big in wind energy is **Mid-American Energy Holdings Co.**, 666 Grand Avenue, P.O. Box 657, Des Moines, IA 50306-0657. Controlled by Berkshire Hathaway, the firm holds MidAmerican Energy Company, PacifiCorp, GE Electric UK, CalEnergy Generation, and others.

A growing energy owner is **Babcock & Brown Wind Partners**, Level 39, Chifley Tower, 2 Chifley Square, Sydney, NSW 2000, Australia. Tel. +612 9229 1800. This is a globally diversified entity investing in wind energy generation in Australia, the United States and Europe.

Horizon Wind Energy, Houston, Texas, with regional offices in New York, Oregon, Illinois, California, Colorado and Minnesota, is now owned by **Energias de Portugal, S.A.** (previously owned by Goldman Sachs). Horizon has developed more than 2,000 MW of operating wind farms. Energias de Portugal is the largest utility in Portugal.

German power company **E.ON** has bought wind farm operations in Spain and Portugal for \$1 billion from DONG Energy, a Danish com-

pany. E.ON already operates 20 on-shore and offshore wind parks in Britain and plans more such projects, including the “London Array,” one of the largest offshore parks worldwide.

The majority (73 percent) of **DONG Energy** is owned by the Danish Government. The company has recently announced plans to build and operate two UK offshore wind farms, Walney Island and Gunfleet Sands II. Walney Island will have 42 turbines and Gunfleet Sands II will have 18.

Other significant owners include **Airtricity**, an Irish firm with numerous wind farms in Europe, and BP’s **Alternative Energy** group, which has begun with 550 MW of wind energy projects.

Wind Energy Developments in the United States

California

In the early 1980s California took the lead in wind farm development. Today many of the early farms are being retrofitted with larger, more efficient turbines. There are estimated to be more than 13,000 wind turbines operating in the state.

Most of California's wind projects are located in three prime areas: **Altamont Pass** (east of San Francisco), **Tehachapi** (southeast of Bakersfield) and **San Gorgonio** (near Palm Springs, east of Los Angeles).

Southern California Edison, the nation's leading purchaser of renewable energy, has signed an agreement with Alta Windpower Development LLC, a subsidiary of Allco Financial Group Inc. of Australia, for 1,500 MW or more of power generated by new projects to be built in the Tehachapi area. The contract, envisions more than 50 square miles (130 sq. km) of wind parks in the Tehachapi region – triple the size of any existing U.S. wind farm. Oak Creek Energy Systems Inc. of Mojave, Calif., is a partner with Allco in the development, construction and operations of the projects.

San Gorgonio Farms has located more than 4,000 turbines in the **San Gorgonio Mountain Pass** in the San Bernardino Mountains between Los Angeles and Palm Springs – generating enough power to meet the

needs of Palm Springs and the entire Coachella Valley.

The Altamont Pass Wind Farm is noteworthy, and some of the nation's most advanced wind power technology is found in **Solano County** in the Montezuma Hills near the Sacramento River delta. In one cluster there are eight turbines, each 415 feet (126 m) tall – more than 200 feet (61 m) taller than the Statue of Liberty. The **Shiloh Wind Power Project**, of PPM Energy in Solano County, has 100 GE units.

In the San Diego area, Superior Renewable Energy has developed the **Kumeyaay Wind Power Project**, with 25 Gamesa units.

Colorado

Spring Canyon, Logan County, 40 GE units. Invenergy Wind.

Idaho

Wolverine Creek, Bingham and Bonneville Counties. 43 GE units. Invenergy Wind.

Illinois

Horizon Wind Energy is building the **Twin Groves Wind Farm** in McLean County. On completion, the project will consist of 240 wind turbines with a capacity of 1.65 MW each, for a total of 396 MW.

Illinois Wind Energy has located its **Crescent Ridge** wind farm in Bureau County with 33 Vestas units.

Iowa

Iowa has nearly 900 wind turbines capable of producing 836 MW of electricity, enough to power about 226,000 average homes, and ranks third in the nation in wind energy behind Texas and California, according to the American Wind Energy Association.

Iowa Winds LLC has proposed to build a \$200 million wind farm stretching across 40,000 acres (16,187 hectares) in **Franklin County** in northern Iowa. The project would be built near Bradford and involve 193 landowners in the townships of Grant, Hamilton, Ingham, Lee, Morgan, Oakland and Reeves.

Another large Iowa venture is the **Century Wind Project**, in Wright and Hamilton Counties: 100 GE units. MidAmerican Energy.

Kansas

Elk River Wind Farm, Butler County: 100 GE units. Empire District Electric Co.

Massachusetts

After years of debate over a wind farm proposed for a site off Nantucket, there is a new proposal that would put the turbines in **Buzzards Bay**. As proposed by developer Jay Cashman, the \$750 million project would involve 120 turbines, each 450

feet (137 m) tall off **Fairhaven** and **Dartmouth**.

Minnesota

Trimont Wind Farm, Martin and Jackson Counties: 67 GE units. **Great River Energy**.

Montana

The early leader in Montana wind energy was the **Judith Gap** farm in Wheatland County, with 90 GE units developed by Invenergy.

Great Plains Wind & Energy has been developing the **McCormick Ranch Wind Park** since 2005. The venture has now been acquired by Naturener, based in San Francisco. Naturener is a Spanish firm.

Naturener has announced plans to double the size of the proposed McCormick project. With the expansion, it would feature some 200 turbines spread across 20,000 acres (8,094 hectares). The \$500 million wind farm is proposed for 10 miles (16 km) west of Shelby between U.S. Highway 2 and the Marias River, in Toole and Glacier counties.

Nebraska

Ainsworth Wind Energy Facility, Brown County, NE. 36 Vestas units. Nebraska Public Power District

New Jersey

Jersey-Atlantic Wind Farm, Atlantic County. 5 GE units.

New Mexico

New Mexico Wind Energy Center near Fort Sumner, having 136 turbines with a peak output of 1.5 MW each. FPL Energy.

San Juan Mesa, Chaves and Roosevelt Counties, 120 Mitsubishi units. Padoma Wind Power.

New York

The **Long Island Offshore Wind Park** is proposed to include 40 wind turbines located several miles off the south shore of Long Island. The 40 turbines would generate 140 MW of emission free power, enough to serve 44,000 homes on Long Island. The wind park will be built and owned by Florida Power & Light Energy.

In 2006, Airtricity began construction of its first New York project, the 34-MW **Munnsville** project east of Syracuse. The company is actively developing four other projects in New York with a total capacity of 200 MW.

The new **Maple Ridge Wind Farm** near Lowville, N.Y., is said to be the second largest wind farm in the United States. This site has 195 Vestas wind turbines, each with a rated capacity of 1.65 MW, resulting in a rated site capacity of 320 MW.

Maple Ridge, formerly Flat Rock Wind Farm, provides about \$10 million in benefits to the local community with about \$2 million annual payments to 75 landowners and \$8 million in tax revenues to the region. This site has increased New York's renewable energy generation by six

fold. The project is jointly owned by PPM Energy and Horizon Wind Energy.

North Dakota

Denali Energy Inc. of Baxter, Minn., and Montgomery Energy Partners LP of Houston, Texas, have entered into a joint venture to develop **Hartland Wind Farm, LLC**. The Hartland Wind Farm will span portions of Burke, Mountrail and Ward counties, about 25 miles (40 km) northwest of Minot. The first phase of Hartland Wind Farm is expected to produce 500 MW, using 333 turbines. A second 500-MW phase is in development. At 1,000 MW, this project has the potential to be one of the largest wind farm developments in the United States.

Wilton Wind Farm, Burleigh County. 33 GE units. FPL Energy.

Velva Wind Farm, McHenry County. 18 Vestas units. Acciona Energie.

Oklahoma

Weatherford Wind Energy Center, Custer County. 98 GE units. FPL Energy.

Blue Canyon II, Comanche and Caddo Counties. 84 Vestas units. Horizon Wind Energy.

Oregon

Klondike II, Sherman County. 50 GE units. PPM Energy.

For a time the largest U.S. wind farm was the **Stateline Wind Project**

on the Oregon-Washington line, with a peak capacity of 300 MW.

Pennsylvania

Bear Creek Wind Farm, Luzerne County. 12 Gamesa units. Community Energy Inc.

South Dakota

A 3,000-MW wind farm is in the early planning stages. Located in South Dakota near the **Iowa border**, it is being initiated by Clipper Wind, led by James Dehlsen, a wind energy pioneer in California. It is designed to feed power into the industrial Midwest around Chicago.

Texas

FPL Energy LLC, a subsidiary of FPL Group, recently announced that it had completed 735 MW of the **Horse Hollow Wind Energy Center** in Texas — making it the largest wind farm in the world. The project includes 291 GE 1.5-MW wind turbines and 130 Siemens 2.3-MW wind turbines spread over nearly 47,000 acres (19,020 hectares) in Taylor and Nolan counties.

FPL Energy, through its subsidiaries, currently operates 47 wind farms throughout the United States with a gross capacity of 4,002 MW — enough capacity to provide electricity for nearly 1 million average U.S. homes. FPL Energy is currently the largest owner and operator of wind turbines in the world.

Airtricity has completed its first North American wind farm — the 124-MW **Forest Creek** project in

West Texas. Airtricity has over 4,000 MW of projects under development in Texas. A consortia involving Airtricity announced a plan to construct a ground-breaking electricity transmission ‘loop’ in the **Texas Panhandle** region. The Loop will be a revolutionary 800-mile (1,287-km) transmission project bringing 4,200 MW of wind energy from the Texas Panhandle to the Dallas-Fort Worth area.

General Electric has announced its tenth investment in a Texas wind farm. The latest project, located east of Lubbock near the town of **McAdoo**, will have 100 wind turbines for a capacity of 150 MW.

Buffalo Gap. Taylor County. 67 Vestas units. **AES**.

Callahan Divide Wind Energy Center, Taylor County. 76 GE units. FPL Energy.

Washington

For a time, the largest U.S. wind farm was the **Stateline Wind Project** on the Oregon-Washington line, with a peak capacity of 300 MW.

Hopkins Ridge Wind Project, Columbia County. 83 Vestas units. RES America.

West Virginia

The **Mountaineer Wind Energy Center** in Preston and Tucker counties has been operational since 2002. It consists of 44 turbines generating 66 MW. The site is owned by FPL Energy.

Wind Energy Developments Around the World

Australia

Epuron Energy, a subsidiary of Co-energy of Germany. Has announced plans for **Silverton Wind Farm**, a \$2 billion, 500-turbine installation – to be Australia’s largest – near Broken Hill in the western part of New South Wales.

Acciona, the Spanish energy company, is building a \$400-million project near **Waubra** in western Victoria with 128 turbines.

Other noteworthy projects include **Emu Downs Wind Farm** and **Alinta/Walkaway** in Western Australia. In South Australia there are projects at **Wattle Point**, Lake Bonney, and **Cathedral Rocks**.

Brazil

To date most of the wind projects in Brazil are small, with less than 100 turbines. Included are **São Gonçalo do Amarante**, Prainha de Aquiraz, and **Mucuripe**, in the state of Ceara; **Fernando de Noronha Island**, and **Olinda**, in Pernambuco; **Morro do Camelinho**, in Mina Gerais; **Palmas**, in Parana; and **Osório**, in Rio Grande do Sul.

Canada

Kruger Energy Port Alma Wind Farm, Chatham Kent, Ontario. Kruger Energy Port Alma Ltd. Part-

nership, 44 Siemens, 2.3-MW Mark II wind turbines.

Other Ontario projects include **Erie Shores, Prince**, and **Huron Wind Farm** in Tiverton. In Quebec there is a farm at **Murdochville**; in Saskatchewan **Centennial**; and in Manitoba at **St Leon**.

Airtricity, an Irish firm with numerous wind farms in Europe, has acquired Toronto-based Gale Force Energy and plans **Canadian projects**.

China

One aggressive Chinese firm recently reported, “As a professional manufacturer of wind towers, we have more than ten years of experience to fabricate towers for mega-watts wind turbines. Our products include V80-2,000-kW-67m of Vestas, 1,500-kW-70m of GE, Z82-HH80-2-MW of Japanese, FL1,500-kW-70m for Dalian Heavy, FD70-1,500-kW for Oriental Turbine Factory, JF1,500-kW-70m for Jinfeng Golden Wind.

“We have worked with Vestas and manufactured 45 units of V80-2,000kW-67m, 40 units of 850kW-V52-55m towers and 25 units of 660kW-V47-42m towers, of which 16 units of V47 towers exported to...

“Also we have cooperated with Gamesa and fabricated 4 units of 850kW-G52-65m towers for

Shanghai Fengxian Gulf Wind Farm, and 12 units of 850kW-G52-55m towers for **Ningxia He Lanchan Wind Farm**, 11 units of 850kW-G52-44m towers for the **Fujian Putian Nanri Island Wind Farm** and 36 units of 850kW-G52-55m towers for Fujian Zhangpu Wind Farm.

“In addition, we supplied 14 units of 600kW-40m towers with NEG-MICON to **Zhejiang Kuo Cangshan Wind Farm**, 7 units of 600kW-50m towers with BONUS to **Fujian Pingtan Island Wind Farm**, 12 units of 600kW-40m towers with JINFENG to **Dalian Xiao Changshan Island Wind Farm**, 26 units of 250kW-30m towers and 2 units of 750kW-50m towers with YUNDA to the **Shandong Changdao Wind Farm**.”

Denmark

Denmark ranks third in Europe in wind power development.

Nysted Offshore Wind Farm is located 6.2 miles (10 km) south of Lolland on Rødsand Bank; 72 turbines, each 230 feet (70 m) tall.

Horns Rev, Denmark’s largest wind farm, is located in the North Sea 9-12 miles (14-20 km) off the coast of Jutland. 80 Vestas, 2-MW turbines.

Germany

Germany has the largest number of wind farms in the world with a total capacity of more than 30,000 MW.

India

India is said to be the fourth largest market in the world for wind energy projects. There are numerous wind farms in the states of Tamil Nadu, Maharashtra, Karnataka and Gujarat.

Ireland

Ireland has approved plans to build the world’s largest wind farm on the **Arklow Sandbank** – a sliver of land 15 miles (24 km) long and just more than half a mile (one km) wide. The site is about 40 miles (70 km) south of Dublin. The new project will have 200 turbines.

Italy

Italy ranks fourth among European nations in number of wind farms.

Japan

Shimamaki Wind Farm, Shimamaki Village, Shimamaki County, Hokkaido. 6 Vestas units.

Sirokitomanai Wind Farm, Wakkanai, Hokkaido. 9 Vestas units.

Minami Osuni Wind Farm, Nejime Town, Kimotsuki County, Kagoshima. 20 Nordex units.

Yohkiku-no-Sato Wind Park, Yuya Town, Ohtsu County, Yamaguchi. 3 Vestas units.

Misaki Wind Park, Misaki Town, Nishi-Uwajima County, Ehime. 20 MHI units.

Nunobiki Plateau Wind Farm on a hill north of Tokyo, generates enough electricity to power some 35,000 homes a year.

Wakamatsu Wind Farm, Kitakyushu.

New Zealand

Genesis Energy has built the **Hau Nui Wind Farm** southeast of Martinborough on the road to White Rock.

Meridian Energy gained approval to build wind farms in the **Makara Hill** area west of Wellington.

Meridian Energy has finished construction of the **Te Apiti Wind Farm** on the Ruahine Ranges near Palmerston North.

The **Te Rere Hau Wind Farm** is under construction.

Meridian Energy's **White Hill wind farm** at Mossburn in the South Island reached full capacity in 2007.

TrustPower purchased the **Tararua Wind Farm**, located on the Tararua Ranges behind Palmerston North, from Tararua Wind Power Limited.

South Africa

Klipheuwel Wind Farm, said to be the first wind farm in subSaharan Africa, comprises three turbines – a Vestas V66 with 1.75 MW output, a Vestas V47 with 660 kW output and a Jeumont J48 with 750 kW output, giving a total output of about 3.2 MW.

Darling Wind Power is developing a wind farm outside Darling in the Western Cape on the Windhoek ("**Windy Corner**") farm. The first phase will consist of four Fuhrlander 1.3-MW turbines.

Spain

Spanish companies, both turbine manufacturers and wind-farm operators, are among the leaders in the global wind-power market. Among these are Gamesa Eólica (turbine manufacturer), Iberdrola (wind-farm owner and operator) and Acciona Energía (wind-farm builder and developer). On a recent weekend, wind farms generated 41 percent of Spain's total energy consumption. The industry currently enjoys a 30 percent annual growth.

Sisante Wind Farm is a 196-MW facility located in Sisante, Cuenca province.

Maranchón Wind Farm, located in Maranchón, Guadalajara, consists of seven smaller wind parks with a total capacity of 208 MW. Owned by Iberdrola.

El Marquesado Wind Farm in Granada is a \$375 million project composed of four farms having a total capacity of 198 MW. Each site has four Gamesa turbines.

United Kingdom

London Array Ltd., a consortium that includes Shell WindEnergy, E.ON UK Renewables and CORE Ltd., is undertaking what is said to be the world's largest offshore wind farm in the Greater Thames Estuary.

The \$3 billion project involves 270 wind turbines deployed on a site about 12 miles (19 km) **offshore between the Essex and Kent coasts.**

The new complex will produce about 1,000 MW of power – enough to supply one fourth of the homes in London. Operation is expected to begin in 2011.

The **Cefn Croes Wind Project** in Wales is the UK's largest onshore wind energy project. Located on a hillside near Devil's Bridge (Ceredigion), about nine miles (15 km) east of Aberystwyth, the project will have 39 GE 1.5-MW wind turbines generating 58.5 MW in total. It has been co-developed by the Renewable Development Company (RDC) and GE Energy, and was recently acquired by

Falck Renewables Ltd. when it took over Cambrian Wind Energy Ltd. RDC and Falck Renewables Ltd. are developing and building more than 300 MW of wind energy projects in England, Scotland and Wales, focusing primarily in Scotland. RDC has also obtained planning approval for the UK's largest offshore wind project (150 MW at **Rhyl Flats**). Falck Renewables Ltd. is a wind energy subsidiary of the Falck Group, an Italian company with headquarters in Milan.

A planned 322-MW wind farm south of **Glasgow** will be the biggest wind farm in Europe. The \$400 million farm is owned by Scottish Power; the 140 wind turbines are to come from Siemens.

Manufacturers of Wind Energy Systems

The leading manufacturers of large wind turbines include Vestas, Gamesa, Enercon, and GE Energy. Competition is intense as many firms around the world vie to market system components such as turbine blades, support towers, generators, gear boxes and controls.

According to the American Wind Energy Association, this multi-billion dollar market grew at a rate of 45 percent last year. The following list presents a cross-section of firms reported to be active.

AAER Inc.: 80, boulevard de l'Aéroport, Bromont, Québec, Canada, J2L 1S9. T: +1.450.534.5155. Electrical components.

ACSA - Aerogeneradores Canarias, S.A.: 35011 Las Palmas de Gran Canaria, Spain. Tel: +34 928257701.

American Superconductor Corp.: Westborough, Mass., through its wholly

owned subsidiary, AMSC Windtec, Klagenfurt, Austria, has landed new orders for its wind turbine electrical systems from customers in Canada and China.

A/S Wincon West Wind: Hedemolle Erhvervsvej 4 DK-8850, Bjerringbro, Denmark . Tel: +45 8668 1700.

Aquitaine Aérogénérateurs: 25, rue St Exupery, Moullets, Gironde France 33350. Tel: 0557402126.

BlueSkyWind, LLC.: 10 New King Street, White Plains, New York 10604. Tel: 914-949-2292.

Bonus Energy A/S: (Brande, Denmark). Mfg of wind turbines. Has been acquired by Siemens Power Generation (Erlangen, Germany).

Dutch Pacific, LLC.: 3835R East Thousand Oaks Blvd. #346, Westlake Village, Calif. 91362.

Carbide Burrs4less: 1623 S. Minnie Street, Santa Ana, California 92707. Tel: 800-854-0449.

Clark Machine Inc.: 423 Glendale Ave., St. Catharines, ON Canada L2V 4B9. Tel: 905-227-5233. FAX: 905-227-8493

Clipper Windpower Inc.: 6305 Carpinteria Avenue, Suite 300, Carpinteria, Calif. 93013. Tel: + 1 805 690 3275.

CSR Zhuzhou Electric Locomotive Research Institute (ZELRI), China, ordered 20 turbines and core components for 1.65 MW of wind turbines.

Denertec S.A.C.: Francisco de Cuellar 635, Urb. San Idelfonso 1, Surco, Lima, Lima Peru LIMA33/ Tel: (51 1) 6281727

Distributed Energy Systems Corporation: 10 Technology Dr., Wallingford, CT 06492-1955.

Dongfang Steam Turbine Works: China, electrical systems for Windtec's 2.5-MW turbine design.

Earth Wind and Power LLC: 208 Camino Manzanitas, Thousand Oaks, CA. Tel: 818-317-2644. Fax: 805-373-0064

Enercon GmbH Intl.: Otto-Lilienthal-Str. 25, D- 28199 Bremen, Germany. Tel: +49 / 421 / 244 15 20. Production facilities also in India and Brazil.

Enercorp LLC: 1101 Pennsylvania Avenue, Sixth Floor, Washington, Washington DC 20004. Tel: 202 756 7739.

Energy Transfer Corporation: RR #1, Sun River, Mont. 59483. Tel: 406-866-2344.

Enertech Wind Systems: PO Box 703, 1800 SE 14th Street, Newton, Kansas 67114. Tel: 1-800-701-2888

Enron Wind Turbine Corp.: Acquired by GE.

Eoltec SAS: 455 promenade des Anglais, Porte de l'Arenas, Hall C, Nice Cedex 3, Alpes Maritimes France 06299. Tel 00 33 (0)6 85 30 35 05.

Entegrity Wind Systems Inc.: P.O. Box 832, Charlottetown, PE Canada C1A 7L9. Tel: 902-368-7171

EU Energy Wind Ltd: Seelandstr. 1, Luebeck, Schleswig-Holstein, Germany 23569. Tel: +49 451 3073 108.

Eurowind Developments Ltd & Eurowind Small Turbines Ltd: 38 Kings Avenue, Newhaven, East Sussex, UK BN9 0NA. Tel: +44 (0) 1273 612383.

Frisa Forjados: Valentin G. Rivero #127 Col. Los Trevino, Santa Catarina, Nuevo Leon, Mexico 66350. Tel: +52-81-8153-0306

Fuhrländer Aktiengesellschaft: Auf der Hohe 4, Waigandshain, Westerwald Germany D-56477. Tel: +49 (0) 26 64 - 99 66 - 0.

Gamesa Corporacion Tecnologica SA: C/ Ramirez de Arellano 37, 28043 Madrid, Spain. +34 915 031 700. One of world's largest wind turbine manufacturers has 32 production centers in Spain, the United States and China. The company's workforce grew from 5,500 in December 2006 to almost 7,000 at the end of 2007, 30% of whom were outside Spain.

GE Energy: 1 River Road, Schenectady, New York 12345. Tel: (518) 385-7343. GE Wind Energy, is a unit of GE Power Systems, based at Marietta, Ga. GE has acquired Enron Corp., mfrs of wind turbines and has become the country's largest manufacturer of turbines and the second-largest in the

world – just a year into operation. Mar 06, 2008, GE Energy announced Second Wind Turbine Agreement exceeding \$1 billion with Invenegy. GE expects more than \$1 billion per year revenue.

Goldwind Science & Technology Co.: China's biggest maker of wind power generation equipment.

Green Energy Technologies: 846 N. Cleveland Massillon Road, Akron, Ohio 44333. Tel 330-388-3701

Harakosan Europe B.V.: Runderweg 6, Lelystad, Flevoland, The Netherlands 8219 PK. Tel: +31 (0) 320291099.

Ingetur S.A.: Pol' Gono Industrial Barasoain, Parcela 2, 31395 Barasoain (Navarra), Spain. Tel: +34 948 720 535.

Lagerwey Wind BV: Barneveld, The Netherlands, Anthonie Fokkerstraat 2, 3772 MR, Barneveld. Das Lagerwey Wind-turbines Ltd., developed plot no. 35, (SP) Guindy Industrial Estate, Madras – 600032, India.

LM Glasfiber A/S: Rolles Mollevej 1, Lunderskov, Denmark 6640. Tel: +45 79 84 00 00.

MADE Tecnologías Renovables: Paseo de la Castellana, 95, Planta 29 Torre Europa, Madrid, Spain. Tel: +34 - 91 - 598 37 28.

Magenn Power Inc.: 18 Monet Court, Ottawa, Ontario, Canada K1T4B6. Tel: 613-733-8488.

Mitsubishi Heavy Industries Ltd.: Environmental Systems Division, 2-5-1, Marunouchi, Chiyoda-ku, 100 Tokyo, Japan. Tel: +81-3-3212 31 11.

Nagalaxmi Industries: 2E3, Dyavasandra Industrial Area, Mahadevapura P O, Bangalore, Karnataka, India 560048. Tel: 91 - 80 - 8510888, 8511086

Natural Energy Processing Co. (NEPC): 36, Wallajah Road, 600 002 Madras, India. Naturener purchased another wind energy developer, Energy Logics (now Naturener Energy Canada Inc.), in southern Alberta.

NEG Micon. Merged with Vestas.

Northern Power Systems: 182 Mad River Park, Waitsfield, Vermont 05673-0999. Tel: (802) 496-2955

Nordex Energy GmbH: Bornbarch 2, 22848 Norderstedt, Germany. Tel (+49) 40 500 98 100.

Nordex Energy GmbH: C. F. Tietgens Vej 10, 6000 Kolding, Denmark. Tel: ++45 - 75 73 44 00.

Nordic Windpower: 125 University Ave., Berkeley, CA 94710. Tel: +1 510 665 9463

Novera Energy: Level 5, The Johnson's Building, 225 George Street, Sydney, Australia 2000. Tel: +61 (0)2 9240 2700.

Ohio Alternative Power LLC: Mason Building 406 Washington Ave, Lorain, Ohio 44052. Tel: +1 216 799-8607

PacWind Inc.: 23930 Madison Street, Torrance, California 90505. Tel: 310-375-9952 x227

Pak Wind Energy (Pvt) Ltd.: M-3 Akbar Paradise Gulshan-e-Iqbal 10 A, Karachi, Sind Pakistan 75300. Tel: +92-21-4971610.

Potencia Industrial SA de CV: Año de Juarez 205, Mexico City, Col. Granjas San Antonio Mexico 09070. Tel: 525 686 7303.

Prime Wind Power International: 828 Block E, Multan Road, Lahore, Pakistan. Tel: +92 42 543 7314.

Renewable Energy House: A15, G/F, Fortune Plaza, 4 On Chee Road, Tai Po, Hong Kong, Hong Kong. Tel: (852) 2717-5814

REpower Systems AG: Alsterkrugchaussee 378, D-22335 Hamburg, Germany. Tel: +49 / (0)40/ 539307-0.

Saba Niroo Co.: P.O. Box 33315/187, Shohada-ye-Sadid St., 9th Km of Saveh Road, Tehran 3319973416, Tehran, Iran. Tel: +98 (21) 5525 6136-7.

Shriram: Leitner Shriram Manufacturing Ltd, a joint venture between Shriram EPC and Dutch firm Leitwind BV. The \$50 million venture will manufacture 1.5-MW wind turbines in its Gummidipoondi plant near Chennai.

Siemens Westinghouse Power Corporation: headquartered in Orlando, FL, Siemens Power Generation, Erlangen, Germany. Siemens Wind Power, (Bonus) Borupvej 16, 7330 Brande, Denmark. Tel: +45 99 42 22 22.

Solect Systems Inc.: PO Box 9157, Bend, Oregon 97708. Tel: (541) 330-2655

Soytes Clean Energy and Electrotechnics Co. Inc.: Tehran Cad. No: 30 Kavakli-dere, Ankara, Turkey 06700 . Tel: +90 3124688 750 .

Suneco Green Energy Co. Ltd: No. 7 Jinan Road, Dongying, Shandong China 257000.

Suzlon Energy Ltd.: World HQ, Amsterdam, Netherlands. +31.20.573.4433. Offices in Aarhus, Jutland, Denmark. Suzlon Wind Energy Corporation, Chicago. Suzlon Wind Energy Corporation, 12626 High Bluff Drive, Suite 370, San Diego, California 92130-2070. Tel: 858-847 0574. Manufacturing facilities in India, the United States, and China. 12,000 employees worldwide.

Südwind Energy GmbH: Centroallee 265, 46047 Oberhausen, Germany D-13507. Tel: ++49-208-8241-0.

Swiger Coil Systems LLC: 4677 Manufacturing Road, Cleveland, Ohio 44135. Tel: 800-321-3310.

Toko Asia Wind Energy: 198-11 47th Ave FL1, Flushing, New York 11358 . Tel: 718-767-3168

Turning Mill Energy: 68 Tupper Rd., Sandwich, Massachusetts 02563. Tel: 774-521-8234.

Vestas Wind Systems A/S: Alsvej 21, 8900 Randers, Denmark. Tel: +45 97 30 00 00. Vestas employs over 13,500 people worldwide. The company has installed more than 33,500 wind turbines in 63 countries and five continents. Vestas has production facilities in Denmark, Germany, China, India, Italy, UK, Spain, Sweden, Norway and Australia and in Colorado.

Wind Energy Solutions bv: De Weel 20, Zijdwind, The Netherlands 1736 KB. Tel: +31 (0)226 425150.

Wind Concepts Ltd: 16 Briarhill Business Park, Ballybrit, Galway, Ireland. Tel +353-(0)91-700077.

Windflow Technology Ltd.: 42-44 Mandeville St., Riccarton, PO Box 42-125, Christchurch, New Zealand. Tel: +64 3 365 8960.

The Wind Turbine Company: 1261 - 120th Avenue NE, Bellevue, WA 98005. Tel 425.637.1470. Fax 425.637.1483. The Wind Turbine Company, Box 40569, Bellevue, Washington 98015 . Tel: 425.637.1470

Winwind Oy: Kaarnatie 38, Oulu, Finland FIN-90530. Tel +358 20 7410 160.

4. Solar Energy Industries

After nibbling away at the fringes of the world energy industry for years, solar energy systems are now joining the big boys – competing for a multi-billion dollar market growing at 50 percent per year.

Jobs! Energy!

It's easy to understand why so many people of ancient civilizations were sun worshipers. The sun gave them light, supported their food crops and brought heat to their cold abodes.

Today millions of people around the world are finding that the sun can also bring them electric power – one of modern man's most vital needs. For those in the development field a long-awaited solar industry boom is underway. Huge solar farms are spreading across the deserts of the world and rooftops everywhere. New industrial plants are springing up to manufacture the equipment they need.

Solar power is well-positioned among all forms of non-fossil and renewable energy sources. Already significant, it will soon become one of the major segments of the world energy supply. Some of the big new solar farms each contain tens of thousands of heliostats – mirrors – laid out for miles across the landscape. They're the kind of customers that make the solar equipment people drool.

The rash of new growth is creating special new opportunities for U.S. development groups. A prime example is the announcement by the

German solar energy firm **Schott AG** that it will build a new plant in the Mesa del Sol area near Albuquerque to produce both photovoltaic (PV) modules and receivers for concentrated solar thermal power plants (CSP). Schott will invest approximately \$100 million to start. That will include a 200,000-sq.-ft. (18,581-sq.-m.) facility that will employ 350 people. Plans call for expansion to 800,000 sq. ft. (74,322 sq. m) with 1,500 employees and an investment up to \$500 million by 2012.

In Texas, thin film producer **Helio-Volt** has announced plans to site their first plant in the Expo Business Park in Austin. The construction will be financed by a record-breaking \$101 million funding round – one of the largest recorded solar power venture capital launches. The new plant will create more than 150 technical and engineering jobs.

Also in Texas, **TekSun PV Manufacturing** is building a plant for making amorphous solar panels in the town of Taylor. TekSun has the support of technology giant Applied Materials that employs approximately 14,000 people throughout Canada, China, Europe, Israel, India, Malaysia, Singapore, Japan, South Korea,

and Taiwan. The company is currently investing some \$400 million in solar projects in Texas, Spain and Germany.

IBC Solar AG, another German solar company, has chosen Cleveland for its U.S. headquarters. The firm recently entered into a partnership with Hyderabad-based **Solar Semiconductor**, a rapidly growing producer of photovoltaic (PV) modules. That deal involves a reported \$575 million.

IBC follows the lead of Sharp in setting up units in the United States. Several years ago the big Japanese firm located its sales and marketing subsidiary, **Sharp Electronics Corporation**, in Memphis. That was Sharp's first solar panel manufacturing facility outside of Japan.

Isofoton, Spain's largest solar panel manufacturer, with more than \$400 million in annual sales, is another global player entering the U.S. market. The firm is said to be looking at sites in Ohio for its first plant in North America.

Meanwhile, **Evergreen Solar Inc.**, manufacturer of the proprietary String Ribbon wafer technology, has undertaken an 80-MW expansion of its Devens, Mass., facility, doubling its capacity to 160 MW and providing 1,000 jobs in Massachusetts.

In Michigan, **PrimeStar Solar Inc.** is planning to double the workforce at its new Montague manufacturing facility. The company recently received a \$3 million contract from the Department of Energy to develop utility-scale thin film solar modules.

The company's CEO cited Michigan's high-skilled manufacturing base and its extended production equipment fabrication network as one of the prime attractions of the location.

R&D connections

The booming solar industry is proving to be a fertile field for venture capitalists and technology incubators. This is giving California's Silicon Valley a fresh shot in the arm. Groups around Palo Alto are investing tens of millions in startups seeking a slice of the global market for renewable energy. A number of firms are adapting technology used for years to produce silicon wafers for computer chips to find new ways to make silicon wafers for solar energy systems.

A good example is **Solaicx**, a startup that is planning its first silicon manufacturing facility. The plant, which will have an initial run-rate of 48 MW, will create about 100 new jobs in its first year. Plans call for expansion to 142 MW of solar ingots and wafers per year.

Another Silicon Valley launch is San Jose-based **SunPower**, a spinoff of chipmaker Cypress Semiconductor. For 2007, the company had revenues of \$775 million, more than three times that of 2006. Revenues were estimated at \$1.2 billion for 2008 and at a growth rate of 40 to 50 percent thereafter.

SolFocus Inc. is a new venture coming out of Palo Alto Research Center (PARC). The combine has developed CPV systems that will deliver lower cost solar electric power and

expects to compete with conventional electricity sources. The company has venture funding of \$32 million.

Nanosolar, the company that invented the cheap, flexible “print out” type of solar cell, will be building a California plant with a proposed output of about 430 MW a year, utilizing venture capital of \$100 million.

Energy Innovations, yet another start-up, has a staff of about 40 people and venture capital investments of \$29 million. The company’s core competencies are in engineering, solar power and software development. The devices it builds require a great deal of integration of all the parts and software to run them.

Another start-up, **Prism Solar Technologies**, will produce a holographic device that separates the most useful part of the light wave for electricity generation using patents licensed from the Illinois Institute of Technology. Starting with venture capital of a little over \$5 million, the small firm hopes to reduce the silicon needed in solar energy systems by as much as 85 percent.

AVA Solar Inc. of Fort Collins, CO, has announced plans for a new PV panel factory, expected to employ up to 500. It will utilize technology developed by mechanical engineering Professor W.S. Sampath at Colorado State University to produce panels that promise to reduce the cost of generating solar electricity to less than \$1 per watt.

On the near horizon are solar systems that are basically more effi-

cient. At Sandia National Laboratories in New Mexico, a combine involving **Stirling Energy Systems** has set a new solar-to-grid system conversion efficiency record of more than 31 percent. The prototype model power plant consisted of a six-dish layout with each dish array having 82 mirrors.

All of these developments have led to an explosive market growth. When we began this study we expected to find several dozen firms active in the field. Now we know there are hundreds. Many of the smaller firms are getting big while we write.

In Germany and Spain where far-sighted officials have been pushing solar energy for years, investors have become accustomed to an annual growth rate of PV systems of 40 to 50 percent. Now, the emergence of big CSP systems has within months created a multi-billion dollar market. Analysts predict a \$200 billion market by 2020.

Of course the future of the solar industry is best where the sun shines brightest and longest. Prime locations in the United States are in California, Arizona, Nevada, New Mexico and other parts of the desert Southwest. In Europe preferred sites are located in Spain, Portugal and arid areas around the Mediterranean.

From **Renewable Energy Access** we learn that “harnessing the sun’s energy falling on just 2,316 sq. mi. (6,000 sq. km) of desert in North Africa would supply energy equivalent to the entire oil production of the Middle East of 9 billion barrels a year.”

Solar Energy Projects in the United States

Arizona

The big news in solar energy in Arizona is the 280-MW “**Solano**” project proposed for a site near Gila Bend. It is a joint venture of Arizona Public Service and Abengoa Solar, a subsidiary of the Spanish utility firm based in Seville. Abengoa has been building solar thermal power generation plants for 20 years in Spain, Morocco and Algeria.

Solano will use parabolic mirrors to follow the sun and concentrate its energy, heating a fluid to 700 F (361 C), and using the fluid to make steam that will spin turbines to generate electricity. The plant will use a new heat storage technology so the plant can continue generating electricity for six hours after sunset.

During three years of construction, the project will employ 1,500 workers at the 1,900-acre (769-hectare) site near Gila Bend. After completion, 80 permanent employees will work at Solano.

Abengoa plans to build a mirror manufacturing facility that will employ 100 workers at a yet-to-be-determined location in the Southwestern United States. Steel structures needed for Solano will be made at an existing Abengoa plant near Monterrey, Mexico.

Solar Two used a molten salt storage to help adjust for cloudy days. The salt storage was 60 percent sodium nitrate and 40 percent potas-

sium nitrate. The molten salt also allowed the energy to be stored in large tanks for future use such as night time.

Tucson Electric Power Co. currently has 26 PV collector systems installed at its **Springerville** generating plant. This facility started operations in 2001 and recently passed the five-year milestone of continuous operations.

California

Back in the 1980s, Luz International, a firm of Israeli origin, was the pioneering commercial developer of U.S. solar thermal electric projects. The company built nine plants, totaling 355 MW of capacity in the Mojave desert near **Barstow**. Despite an impressive start, the program came a cropper as result of intermittent government support, high costs, and technical problems. Luz had to file for bankruptcy in 1991.

After some years of frustrations, the California solar energy business is again active. The state government launched a **Million Solar Roofs Initiative** in 2006 – part of a statewide effort to install 3,000 MW of new, grid-connected solar systems by 2016. The program provides \$1.167 billion in rebates and cash incentives on solar systems to customers of Pacific Gas and Electric Co., Southern California Edison, and San Diego Gas and Electric Co.

Project New America

The program has enticed large-scale solar energy developers to invest in California projects. Most notable is FPL Energy – an affiliate of Florida Power and Light. FPL has joined with Israel-based Solel Solar Systems to undertake a 550-MW **Mojave Solar Park**. Solel had previously acquired the former Luz property in the Mojave.

The project will deliver 553 MW of solar power to PG&E’s customers in northern and central California. When complete, the Park will cover up to 6,000 acres (2,428 hectares), or nine sq. mi. (24.3 sq. km). The plant will use Solel’s solar thermal parabolic trough technology with 1.2 million mirrors and 317 miles (510 km) of vacuum tubing to capture the sun’s heat.



Engineers working at the Solar Energy Generating Systems (SEGS) facility in the Mojave Desert



Solel and FPL Energy layout in Mojave desert.

Meanwhile, Stirling Energy Systems of Phoenix, Ariz., has announced plans for a 500-MW solar project at **Victorville**, 70 miles (113 km) northeast of Los Angeles, to serve Southern California Edison and San Diego Gas and Electric. Using Stirling-engine/solar-dish technology the project will deliver enough power to run half a million homes. The plan contains an option to expand the project to 850 MW. The 20,000-dish array would be expanded to 34,000.

A San Francisco-based start-up, Cleantech America, is preparing to develop several 80-MW facilities in California. The firm is planning with Pacific Gas and Electric to build one of the world's largest and most advanced photovoltaic solar power stations, CalRENEW-1, in the **San Joaquin Valley** near Fresno. It will cover about 600 acres (243 hectares).

In addition, Brightsource Energy, an Oakland-based firm, plans to develop a 400-MW solar thermal power complex in the **Mojave** desert, utilizing Distributed Power Tower (DPT) technology developed by Luz II. It consists of mirrors that reflect the sun's light to a central tower to heat water and run a steam turbine to create electricity.

Also, Austra, a Palo Alto start-up, has announced plans for a 175-MW solar thermal power plant in **Central California**. Begun five years ago as an Australian company called Solar Heat and Power, Austra relocated to Palo Alto last year with the backing of well-respected technology investors Khosla, a co-founder of Sun Microsystems, and Ray Lane, the for-

mer president of Oracle. Both sit on the company's board.

Southern California Edison has launched a project that will place 250 MW of advanced photovoltaic generating technology on 65 million sq. ft. (6,038,698 sq. m) of roofs of **Southern California** commercial buildings – enough power to serve approximately 162,000 homes.

Colorado

The pioneer here is the **Alamosa Photovoltaic Solar Plant San Luis Valley**, at Alamosa with a capacity of 8 MW.

District of Columbia

The new bill, H.R. 798, directs the General Service Administration to spend \$30 million for a 300-ft. (91.4-m) long, 130-ft. (40-m.) high solar array on the south wall of the DOE headquarters (also known as the **James Forrestal Building**), located on Independence Avenue.

Idaho

Avista Utilities and a startup San Francisco company plan to test a new solar power system in **northern Idaho** that could provide an electricity boost to help relieve peak summertime energy use. **GreenVolts Inc.** will try out its utility-scale, sun-tracking solar array, billed as more cost-effective than traditional models, near an Avista substation in **Rathdrum**. It will be the first project at the utility's new test bed for clean energy sources.

Produced by Spokane Valley-based **Ecolite Manufacturing Co.** and backed financially by Avista and other local investors, the prototype system could initially generate about 2.4 kW, enough electricity for two homes.

With about 200 employees, Ecolite expects revenues of about \$20 million this year. Ecolite CEO Caferro said the company already is expanding his 80,000-sq.-ft. (7,432-sq.-m.) manufacturing plant by 12,000 sq. ft. (1,115 sq. m), and he expects to double his work force if GreenVolts takes off.

Massachusetts

The U.S. Department of Energy created a “Brightfields” program to describe an abandoned or contaminated property (brownfield) redeveloped to use solar technology. A pioneering project is located in **Brockton**.

Nevada

The Spanish firm Acciona Solar Power (formerly Solargenix) has

launched a 64-MW project called **Nevada Solar One** located near Boulder City. The project covers 300 acres (121 hectares) and contains 760 mirror arrays with a total of 184,000 mirrors. The parabolic trough plan features the Solargenix SGX-1 collector. The mirrors direct sunlight on an oil-filled tube. The oil is then used to create steam, which turns a turbine. The Boulder City plant will sell power to Nevada Power Co. of Las Vegas and Sierra Pacific Power Co. of Reno.

Another significant solar project in the state is an installation at the **Nellis Air Force Base**. It has a capacity of 14 MW.

New Mexico

Two Arizona companies, New Solar Ventures and Solar Torx, have announced plans for a \$650 million solar photovoltaic panel factory and power plant near **Deming**. The 300-MW facility is projected to occupy about 2,500 acres (1,012 hectares), employ several hundred people, and begin operations by 2011.

A Glimpse at Solar Energy Projects Around the World

Australia

In 1996, an Australian company, **Solar Systems**, successfully converted 14 solar thermal concentrators to photovoltaic power generation. They were installed in the 1980s at **White Cliffs, South Australia**.

Solar Systems has also constructed four new concentrator dish power stations at **Hermannsburg**: (192 kW), **Yuendumu** (240 kW), **Lajamanu** (288 kW), and **Umuwa** (220 kW). Together they generate 940 kW.



Solar concentrating PV dishes at Yuendumu in Australia's Northern Territory

Solar Systems is also developing a \$420-million, large-scale solar power plant near **Mildura in north-west Victoria**. The 154-MW solar power station is planned to have 250 heliostats (sun tracking mirrors) in multiple arrays. The firm is to receive a \$75 million grant for the project under the federal government's Low Emissions Technology Demonstration Fund (LETDF).

Germany

The German government asserted leadership in 1998 with a bold program to achieve 100,000 rooftop PV installations within 10 years. The law provided low-interest loans for rooftop PV systems. The program was so successful that the target was met in five years. This was a powerful boost for German firms producing PV system components.

The Juwi group, based in Bolanden in the state of Rhineland-Palatinate, has developed one of the world's biggest photovoltaic (PV) power plants at a former military air base at **Brandis**, east of Leipzig. The 40-MW solar power plant uses state-of-the-art thin-film technology.

Shell Erneuerbare Energien GmbH and Saint-Gobain Glass Deutschland GmbH recently announced plans to create AVANCIS to exploit Shell's Copper-Indium-Selenium (CIS) thin-film technology. AVANCIS will build a manufacturing plant in **Torgau** to produce photovoltaic panels using the CIS technology. A 25-MW polycrystalline facility was built in **Gelsenkirchen** by Royal Dutch Shell and Pilkington Solar International.

What at one time was reported to be the world's largest PV solar power plant is located in **Pocking**. It has a capacity of about 10 MW. Another early leader was the installation in the **Muldentalkreis** district in the state of Saxony, rated at 12 MW.

Other significant projects include: **Solarpark Gut Erlasee**, Erlasee/Arnstein, 12 MW; **Solarpark Penzing**, Penzing, München 3.5-MW; and **Solarpark Mehringer Höhe**, Mehring, Trier-Saarburg, 3.5 MW.

Israel

Preliminary plans have been announced for three large solar plants near **Ashalim** in the Negev desert. Two of the facilities would be mirror arrays generating about 100 MW each. The third would be a PV plant with a capacity of 15 MW. Total cost would be about \$700 million.

Japan

Following Germany's lead, Japan launched a 70,000-roof PV program that has accelerated solar development. Well-known **Sharp** is a major producer with a plant at **Kameyama**.

Also, world-famous Honda Motors has established a wholly owned subsidiary, **Honda Soltec Co. Ltd.**, to produce thin film solar cells developed by Honda Engineering Co. Ltd., the production engineering subsidiary of Honda. Honda Soltec's new 27-MW manufacturing plant is located at the current site of Honda's **Kumamoto** factory.

Portugal

Blessed with one of the best locations in Europe for capturing solar energy, Portugal is moving boldly with a gigantic project at **Moura** in the Alentejo region. When fully developed, the new solar farm will have 376,000

solar panels. The first stage will have 190,000 fixed and 52,000 on trackers. Costing \$254 million, the farm covers over 300 acres (121 hectares).

Acciona Energy, the Spanish conglomerate, was selected to build and operate a 62-MW plant. Acciona acquired 100 percent of the shares of Amper Solar – owner of the rights to the solar plant authorized by the Portuguese Ministry of Economy.

To supply the components for the huge new farm, the company located a PV panel manufacturing plant in **Moura** with a minimum annual production capacity of 24 MW. Also, the firm gave \$4 million to the social fund of the poverty-stricken area for infrastructure improvements.

Spain

One of the most impressive solar projects in Europe is taking shape at **Seville**. Beginning in 2001, elements have been added to an **Abengoa** complex that will rival anything in the world. Overall, investment will be about \$1.6 billion.

The project began with an 11-MW plant in the municipality of **Sanlúcar la Mayor** about 16 miles (25 km) west of Seville. New components will result in a 300-MW facility by 2013. The development program includes the PS10, the world's first tower technology solar thermoelectric power plant constructed for commercial operation, and Sevilla PV, the largest low concentration system photovoltaic plant – yielding a diverse technology macro-project that includes tower thermoelectric, parabolic-trough collector, Stirling

dish, and low and high concentration photovoltaic plants.

The huge project being developed by Solúcar, an Abengoa affiliate, will meet the power needs of the Seville area and contribute greatly to the economy of the Aljarafe district. Benefits will include 1,000 jobs during construction phases and some 300 for maintenance and service.

Another Spanish company, SENER, is developing **Andasol 1**, the first parabolic trough plant in Europe, a 50-MW system outside Granada.

Other projects include: **Parque Solar Hoya de Los Vincentes**, Jumilla, Murcia. 23 MW; **Solarpark Beneixama**, Alicante. 20 MW;

Planta Solar de Salamanca, Salamanca. 13.8 MW; **Solarpark Lobosillo**, Murcia. 12.7 MW; and **Huerta Solar Monte Alto**, Milagro. 9.5 MW.

Abu Dhabi's Masdar Initiative and Spain's Sener engineering firm have formed a joint venture to build and operate concentrating solar power plants across the world's sunbelt regions. The JV called Torresol Energy, will be 60 percent owned by Sener, an engineering group, with 40 percent held by Masdar, the Abu Dhabi government's umbrella group for all of its renewable projects. The venture's first order of business is to start work on three solar power plants in Spain with combined value of \$1.2 billion.

Some Companies Developing Solar Energy Systems

Abengoa is a large Spanish-based diversified energy company. Its affiliate **Solúcar** is its active solar business unit.

Acciona: One of Spain's largest corporations, with activities in more than 30 countries on five continents with projects in renewable energies, and other infrastructures. The firm has a workforce of more than 38,000. +1-212-593-6377, +1-860-810-5657, guerink@ruderfinn.com. Includes Acciona Solar Power (formerly Solargenix), and Acciona Energy Oceania Pty Ltd, Level 1, 95 Coventry St., South Melbourne, VIC 3205, Australia.

AES Ltd.: AES Building, Lea Road, Forres IV36 1AU. E-mail: info@aessolar.co.uk. Phone: +44 (0)1309 676911. AES is the UK's original solar thermal collector manufacturer and has been manufacturing collectors since 1979.

AES Solar. Corp., Arlington, Va., and **Rivertone Holdings LLC**, New York City, have formed a joint venture in which AES Solar will invest \$1 billion in next five years in new PV installations at sites yet to be named.

Akeena Solar, Los Gatos, Calif., a solar panel installation firm with 50 employees.

Al-Afandi Solar Wafers and Cells Factory, 21411 P.O. Box 452, Jeddah, Saudi Arabia. Tel: 966 2 6634442.

Amper Solar. Acciona has acquired 100% of the shares of Amper Solar.

Applied Films. Bought by Applied Materials.

Applied Materials. 3050 Bowers Avenue, P.O. Box 58039, Santa Clara, CA 95054-

3299. Tel: 1-408-727-5555. Applied Materials creates and commercializes nano-manufacturing. The firm employs approximately 14,000 people throughout Canada, China, Europe, Israel, India, Malaysia Singapore, Japan, South Korea, Taiwan, and the United States. They produce: semiconductor (aka integrated circuit) chips for all electronic gear, flat panel displays for computers and television, glass coatings for homes and buildings, web (flexible substrate) coaters for industry, and PV solar cells and modules using both thin film and crystalline photovoltaic technology.

Arise Technologies. 65 Northland Road Waterloo, Ontario, Canada. N2V 1Y8. 1-877-274-7383. Produces PV solar cells.

Ascent Solar. Littleton, Colorado, a developer of thin-film photovoltaic modules.

Ausra Solar Heat and Power, Palo Alto, CA. Thermal power installations.

Avancis. Shell Erneuerbare Energien GmbH and Saint-Gobain Glass Deutschland GmbH, recently announced plans to join forces and create Avancis – an entity that will develop, produce and market next generation solar technology based on Shell's advanced Copper-Indium-Selenium (CIS) thin-film deposited on glass.

AVA Solar Inc., 4557 Denrose Court, Unit B, Fort Collins, CO 80524. Phone: (970) 472-1580. Founded in 2007 to commercialize an advanced process for manufacturing cadmium telluride (CdTe) thin-film photovoltaic modules – using 15 years of development at Colorado State University's Material Engineering Laboratory,

Bangkok Solar Co. Ltd., 39/1 Moo 1, Bangpakong-Chachoengsao Road, Sanpudad, Banpho, Chachoengsao 24140, Thailand. Tel: 66(0) 3857-7373.

Bharat Electronics Limited, 2nd Floor S.N. Bldg, 25 M.G. Road, Bangalore - 560 001, India. Tel: 91 80 5595729. PV components. Bharat Heavy Electricals Limited. Integrated Office Complex, Lodhi Road, New Delhi -110003, India. Tel: 91 11 51793242.

Big Sun Energy Technology. No.458, Sinsing Rd., Hukou Township, Hsinchu County 303, Taiwan (R.O.C.). Tel: 886-3-5980288.

BIPV companies. BIPV stands for Building Integrated Photovoltaics and refers to *solar energy technologies* that are integrated into a building's façade or roof. There are numerous firms offering BIPV.

Bloom Energy. Silicon Valley venture heavyweights Kleiner Perkins Caufield & Byers and New Enterprise Associates are backing Bloom Energy, a solid-oxide fuel cell company that has raised \$102 million.

Boading Yingli. No.3055, Fuxing Middle Road, National New & High-tech Industrial Development Zone, Baoding, China. Pos: 071000. Tel: 86 312 3100509. PV materials.

BP Solar. 630 Solarex Court, Frederick, Maryland 21703. Tel: 1 301 698 4200. The parent firm, BP, has been involved in solar power since 1973 and its subsidiary, BP Solar, is now one of the world's largest solar power companies with production facilities in the United States, Spain, India and Australia, employing a workforce of over 2,000 people worldwide. BP Solar is a major worldwide manufacturer and installer of photovoltaic solar cells for electricity. The company has begun constructing two new solar photovoltaic solar cell manufacturing plants, one at its European headquarters in Tres Cantos, Madrid, and the second at its joint venture facility, Tata BP Solar, in Bangalore, India.

BrightSource Energy Inc., 1999 Harrison Street, Suite 2150, Oakland, CA 94612. Tel: 510-550-8161 x108. E-mail: info@brightsourceenergy.com

CarouSol systems include 176 units, each containing a mirror that focuses sunlight onto a one-centimeter-square solar cell made by a Boeing subsidiary, Spectrolab. The steel units rotate around a circular track and tilt vertically, allowing them to track the sun all day.

Canon Inc., E Business Division. 3-30-2, Shimo-Maruko, Ohta-ku, Tokyo 146-8501, Japan. PV systems.

Canrom Photovoltaics Inc., 108 Aikman Avenue, Hamilton, Ontario, Canada L8M 1P9 Tel: 1 905 526 7634.

Central Electronics Limited. 4 Industrial Area, Ghaziabad, 201 010, Sahibabad, India, Tel: 91 120 2895165. PV materials.

China Biotech Holdings Limited, China Merchants Zhangzhou Development Zone. Manufactures PV solar thin film base plates.

China Electric Equipment Group. Zhongdian Avenue, Yangzhong. China. Tel: 0086-25-83275370. E-mail: leo@ceeg.com; one of China's largest producers of PV components. The CEEG consists of several subsidiary companies, namely, Jiangsu CEEG Electrical Equipment Manufacturing Co Ltd, Jiangsu CEEG Electrical Transmission and Distribution Equipment Co. Ltd., Jiangsu CEEG Transformer Manufacturing Co. Ltd., Shanghai DuPont Electrical Equipment manufacturing Co. Ltd., Jiangsu East China Microwave Instrument Co. Ltd., and CEEG Shenyang Institute.

China Sunenergy. No. 123, Fochengxilu, Nanjing Jiangning Economic & Technical Development Zone, China, PC: 211100. Tel: +86-25-52766688. E-mail: info@chinasunergy.com

Cypress Semiconductor, San Jose. A long-established chip maker. In 2005 launched a spin-off Sun Power, based in San Jose.

DayStar Technologies. Has signed a letter of intent with **Juwi Solar GmbH**, one of the leading companies in the renewable energy sector in Europe. The LOI identifies Juwi Solar GmbH as a sales partner for DayStar in commercializing its CIGS glass modules.

Ecolite Manufacturing Co., Spokane Valley. With about 200 employees, Ecolite expects revenues of about \$20 million this year. PV components.

Energy Conversion Devices Inc. Ovonic. 2956 Waterview Drive Rochester Hills, MI 48309, Tel: 1 248 293 0440. PV components.

Energy Photovoltaics Inc. 276 Bakers Basin Road, Lawrenceville, NJ 08648, Tel: 1 609 587 3000.

Eoply New Energy Technology Co Ltd., No. 8, West Hainan Rd., Hainan, Jiangsu 226611, China. Tel: 86 88782787. Solar.

ErSol Solar Energy AG. Wilhelm-Wolff-Str. 23 99099 Erfurt, Germany. Tel: 49 3 61 4 42 46 - 0.

ESolar Inc., a Pasadena, CA-based company launched by Google. ESolar heliostats are designed to minimize cost, realizing economy-of-scale benefits at much smaller power plant sizes than traditional solar thermal plants.

ET Solar Group. ET Solar China. 24F, A2 World Trade Center, Mansion 67 Shanxi Rd., Nanjing 210009, China. 86 25 8689-8096, 8689-8098, sales@etsolar.com. ET Solar US, 4900 Hopyard Road, Suite 290 Pleasanton, CA 94588, (925) 4609898. sales@etsolar.us

E-Ton Solar Technology. No. 498, Sec. 2, Bentian Rd., Tainan, Taiwan, 709 Tel: 886-6-3840777

Evergreen Power Limited. 14-16 Hillwood Road, Suite 7-B, Tsim Sha Tsui, Hong Kong, Hong Kong 00001. Tel 852 9673 6227. Photovoltaic modules.

Evergreen Solar Inc. 138 Bartlett Street, Marlboro, MA 01752 Tel: +1 508.357.2221. info@evergreensolar.com

First Solar LLC., 4050 E Cotton Center Blvd. Suite 6-69, Phoenix, Arizona 85040, Tel: 1 602 414 9300

Free Energy Europe. 2, Rue Leon Droux, BP 66, 62302 Lens Cedex, France. Tel: 33 03 21 79 30 60. Solar.

Fuji. 2-2-1 Nagasaka Yokosuka, Chiyoda-ku, 240-01, Kanagawa, Japan Tel: 81 46 857 67 30 PV.

Flagsol GmbH. Agrippinawerft, 22, 50678 Koln, Germany. www.flagsol.com . A pio-

neering developer of parabolic trough collectors. Large projects in California.

Flabeg GmbH & Co. KG. Waldaustraße 13, 90441 Nürnberg, Germany. +49 (0)911 - 96 456-245. A leading manufacturer of high-precision solar mirrors. Flabeg developed a measurement process in cooperation with MAN as part of the "Ariane" aerospace program.

FPL Energy. Subsidiary of Florida Power and Light. P.O. Box 14000, Juno Beach, FL 33408-0420. 561-691-7171.

Frontway Enterprise Co. Gong Gang Mission, 16 Fuzhou South Road, Qingdao 266071, China. (+86) 532 - 8597 1349. www.supesolar.com.

GE Energy (Solar Division). 231 Lake Drive, Newark, Delaware, Tel: 1 302 451 7500.

Gintech Energy. 8F, No. 396, Nei Hu Rd., Sec.1, Taipei 114, Taiwan. Tel: 886-2-2656-2000. Solar.

Google. The global information giant has entered the renewable energy field with a spin-off, **eSolar Inc.**, based in Pasadena.

Green Energy. See Yingli.

GreenVolts Inc. 50 First Street, #507, San Francisco, CA 94105. info@greenvolts.com, 415 963-4030. A solar start-up with \$1.5 million venture capital.

HelioDynamics Inc., 23 Dos Posos, Orinda, California 94563. Tel: 925 254 5250. E-mail: jepsen@heliodynamics.com. Offers solar concentrators designed to be mounted on roofs, on parking lots and in open-field sites.

Heliodomi S.A. P.O. Box 60212, Thessaloniki 57001, Thessaloniki, Greece. Tel: 30 310 469 140.

Heliodinâmica. Rodovia Raposo Tavares km 41, Vargem Grande Paulista - CEP 06730-970, Caixa Postal 111, São Paulo, Brasil. Tel: 11 4158-3511

Helios Technology srl, Via Postumia 11, 35010 Carmignano di Brenta (PD), Italy

Huamei PV Company. No.86 Jianguolu, Qinhuangdao, Hebei, China 066000, Tel: 86 335-3035394.

IBC Solar AG, Am Hochgericht 10, 96231 Bad Staffelstein, Germany. Tel: +49 9573 9224-0

ICP Solar Technologies Inc., 6995 Jeanne-Mance Montreal, Quebec, Canada H3N 1W5. Tel: 1 514 270 5770

Iowa Thin Film Technologies. 2337 230th Street, Boone, Iowa 50036. Tel: 1 515 292 7606

Isofotón SA. c/ Montalbán No9, 2 Izq., 28014 Madrid, Spain. Tel: 34 91 531 2625

Jadoo Power, Folsom, CA. Whether produced by the sun, wind, or hydrogen, energy needs to be captured. Jadoo Power, a **Mohr Davidow**-funded company based in Folsom, Calif., is producing small hydrogen fuel cells for the military and consumers. Eventually it plans to sell a rechargeable hydrogen fuel cell that can power an entire home.

Jiangsu Huayang Solar Energy Co. Ltd
JingAo Solar Co. Ltd., JingLong Industrial Park, JingLong Street, NingJin County, Xingtai, Hebei, China 055550 Tel: 86 319 580 0751

Juwi Solar GmbH, Bolanden, Rhineland-Palatinate, Germany. Has developed more than 600 photovoltaic power plants with a total capacity of 80 MW. Partner of **Day-Star U.S.** using photovoltaic products based on copper indium gallium selenide, or CIGS, thin-film semiconductor technology.

Kaifeng Solar Cell Factory. No.45 Xinhua Dongjie, Kaifeng, Henan, China 475000, Tel: 86 378 597722

Kaneka Corporation. 3-2-4, Nakanoshima, Kita-ku, Osaka 530-8288, Japan. Tel: 81 6 6226 5237. PV products.

Konarka Technologies Inc., Lowell, Mass., has raised \$32 million from ChevronTexaco, utility company Electricité de France and venture capital firm Draper Fisher Jurvetson. Konarka, which counts

Nobel Prize winner Alan Heeger as a founder, will produce solar cells made of thin layers of plastic.

Kvazar JSC. 3 Severo-syretskaya str., 04136 Kiev, Ukraine. Tel: 81 75 604 3476. Solar.

Kyocera Corporation (Solar Energy Division). Kyocera Corporation Headquarters Building, 6 Takeda Tobadono-cho, Fushimi-ku, Kyoto 612-8501, Japan. Tel: 380 (44) 205 34 50. Kyocera Solar Inc., (US Division). 7812 East Acoma, Scottsdale, Arizona 85260, Tel: 1 480 948 8003. Kyocera Corporation has announced plans to reinforce production bases in Japan, the U.S., Europe and China, investing a total of about \$307 million through FY2010.

LDK Solar Co. Ltd., Hi-Tech Industrial Park, Xinyu City, Jiangxi province, China. U.S. office in Sunnyvale, California. IPO \$300 million to finance two polysilicon plants currently under construction in China.

Maharishi Solar Technology Pvt. Ltd., A-14, Mohan Co-operative Industrial Estate, Mathura Road, New Delhi-110 044, India. Tel: 91 11 6959701

Matsushita Battery Industrial Company. Photovoltaic Division, 1-1 Matshushita-cho, Moriguchi-shi, 570-8511, Osaka, Japan. Tel: 81 (0)6 6991 1141

Matsushita Seiko Co Ltd., 4017, Shimonakata, Takaki-cho, Kasugai, Aichi, 486-8522, Japan. Tel: 81 0568 81 1511. Solar.

Microsol International, P. O. Box 4940, Fujairah Free Zone Phase II, Fujairah, United Arab Emirates 4940, Tel: 00971-9-2282138. PV.

Mitsubishi Electric Corporation. Mitsubishi Denki Building 2-2-3, Marunouchi, Chiyoda-ku, Tokyo 100-8310, Japan. Tel: 81-3-3218-2111. PV. Mitsubishi Heavy Industries (Power Systems Division) 5-1 Marunouchi 2-Chome, Chiyoda-ku, Tokyo 100-8315, Japan. Tel: 81 (0)3 3212 9408

Moser Baer Photovoltaic. 43 B, Okhla Industrial Estate, New Delhi 110020, India. Tel: 9141635201

Motech Industries Inc. Solar Electricity Division, No 3 Da-Shun 9th Road, Tainan County, 744, Hsin-Shi, Taiwan. Tel: 886 6 505 07 89 x204

Nanosolar, a Palo Alto company, has more than \$100 million in funding. The company has developed a cheap flexible "print out" type of solar cell.

Nanosys of Palo Alto is working with Matsushita on sprayable solar coatings for roofs.

Neo Solar Power Corp., 2, Wen-Hua Rd., Hsinchu Industrial Park, Hu-Kou, Hsinchu County, Taiwan 303. Tel: 886-3-598-0126

New Solar Ventures. Arizona firm.

Ningbo Solar Energy Power Co. Zhou Fuuzhang, 315012 No 80 Qiafengjie, Ningbo, Zhejiang, China. Tel: 91 44 4836 351

Open Energy, www.openenergycorp.com bought Toronto-based Solar Roofing Systems and its patented BIPV roofing membranes, SolarSave. Also, acquired Connect Renewable Energy Inc. – maker of BIPV roofing tiles. Has \$20 million in financing.

Pacific SolarTech. A Silicon Valley start-up.

Pentafour Solec Technology Limited (licensee of Solec International), Chitra Towers, 332-2 Arcot Road, Kodambakkam, Chennai 600 024, India. Tel: 86 574 712 1761

Perlight Solar Co. Ltd

Photon Semiconductor & Energy Co. Ltd., 300, Cheoncheon-dong, Jangan-gu, Suwon-si, Gyeonggi-do, 440-746 Korea. Tel: 82 55 294 2116. PV.

Photovoltech NV SA. Grijpenlaan 18, 3300 Tienen, Belgium. Tel: 32 1 6805-850

Photowatt International SA, 33, rue St Honore, ZI Champfleuri, 38300 Bourgoin, Jallieu, France. Tel: 33 (0)474 93 80 20

Polar Photovoltaics. 268 Tanghe Road, Bengbu, Anhui 233030 China. Tel: 86 552 3178212

PowerLight, the nation's biggest solar panel installer.

PrimeStar Solar Inc., HQ, 13100 W. 43rd Drive, Golden, CO 80403-7232. 303-278-3180.

Prism Solar Technologies, PO Box 630, Stone Ridge, NY 12484. Tel 845.943.5374. info@prismsolar.com

Q-Cells AG. Guardian str.16, D-06766 Thalheim, Germany. Tel: 49 3494 66 86-0. The world's second largest cell manufacturer

ReneSola. Shanghai, China. Raised \$130 million in a stock offering on the New York Stock Exchange.

Renewable Energy Corporation, based in Norway, has seven production plants in three different countries with approximately 1,100 employees. Producer of polysilicon and wafers for PV applications.

Sanyo Electric Co Ltd.: Soft Energy Co., Business HQ. 222-1, Kaminaizen, Sumoto City, Hyogo 656, Japan. Tel: 81 799 23 2901. Produced \$213 million worth of solar cells at its plant in Hungary in recent year.

Schott Solar Industrie. straÙe 13, Alzenau, Germany. D 63755. Tel: 49 (0)6023 91-17 12. One of the world's largest producers of solar photovoltaic technologies. Schott employs over 900 people and has worldwide production capacity of over 130 MW.

Sharp Corporation, Sharp Photovoltaics Div., 282-1 Hajikami, Shinjo-cho, Kita-Katsuragi-gun, Nara Prefecture 639-2198, Japan. Tel: 81 745 63 3579. Sharp is the world's largest photovoltaic module and cell manufacturer, with major plants in Japan and in the UK. Sharp Solar produces solar cells for many applications, from satellites to lighthouses, and industrial applications to residential use. Recently the firm undertook to build a new state-of-the-art LCD panel plant and solar cell plant for the mass production of thin-film solar cells in Sakai City, Osaka prefecture. This project is

being developed as a "manufacturing complex for the 21st century."

Shecom K.K., ShecomBldg, 2-22, Kotono-Cho, 3 Chome, Chuo-ku, Kobe, Hyogo, Japan 651-0094. Tel: 81-78-232-1974. Solar electric power systems, batteries lithium ion, LED lighting.

Shenzhen Topray Solar Co Ltd., 6th Floor, 2nd Block, Yuezhong Industrial Area, Zhuzilin, Futian Shenzhen, Guangdong, China 518040. Tel: 86 755 3709226

Signet Solar, recently signed a contract to buy turnkey production lines from Applied Materials.

Sinonar Corporation, 8 Prosperity Road 1, Science-Based Industrial Park, Hsinchu, Taiwan. Tel: 886 3 5783366. Solar.

SkyFuel was awarded a grant by the U.S. Department of Energy to develop its advanced CSP/LPT system. LPT is a high-temperature linear Fresnel system with molten salt storage.

Sky Solar International Co. Ltd., Hong Kong.

Solaicx, a Silicon Valley startup that manufactures silicon wafers.

Solarfun. 666 Linyang Road, Qidong, Jiangsu Province, China 226200. Solarfun - Eugene, Oregon 7405. Tel: 1-541-228-8888. sales@solarfun.com.cn

Solarfun Power Holdings Co. Ltd., Solarfun Power. 218 Wusong Road, BM Tower, 26th Floor, Shanghai, China 200080. Tel: 0086 21 6307 0222

Solar Power Industries. 13 Airport Road Belle Vernon, PA 15012. Tel: 1 724 379 2001

Solar Reserve, 2425 Olympic Blvd., Suite 6040 West, Santa Monica, CA 90404. 310-449-8680. A collaboration between United Technologies Corporation (UTC), a Dow 30 conglomerate, and US Renewables Group, a private equity firm focused exclusively on renewable energy. SolarReserve holds the exclusive worldwide license to build state-of-the-art Concentrated Solar Power (CSP)

plants that use equipment manufactured by HS Rocketdyne, a subsidiary of UTC. Rocketdyne, in partnership with the U.S. Department of Energy, has invested \$100 million in the design and manufacture of these components,

Solar Semiconductor recently purchased a Solar PV Module manufacturing line from P. Energy S.A.S. of Italy.

Solar Systems. 322 Burwood Road, Hawthorn Victoria 3122, Australia. +61 3 8862 8100

SolarWorld AG. Kurt-Schumacher-Str. 12-14, 53113 Bonn, Germany. Tel: 49 - (0) 228 / 55 92 00

Solar Cells (formerly Koncar Solar Cells), Tezacki put BB, 21000, Split, Croatia. Tel: 385 21 374 510

Solartec s.r.o., 1 Máje 1000/M3, CZ- 756 64 Roznov pod Radhostem 3, Czech Republic, E-mail: solartec@solartec.cz

Solartech Energy Corp., No. 51, Dinghu 1st St., 4th Industrial Park, Gueishan, Taoyuan 333, Taiwan.
E-mail: sales@solartech-energy.com

Solar Torx. New Arizona firm.

Solar Wind Ltd., 15, Korotkaya str., Krasnodar, 350063 Russia.
E-mail: solwind@mail.kuban.ru

Solar Wind Europe S.L., C/Doctor Esquerdo, 17-2^o, 28028 Madrid, Spain. Pol. Ind. Las Casas II, C/ L, nave 227, 42005 Soria, Spain.
E-mail: info@solar-windeurope.com

Solargenix Energy - The Winston Series CPC is a Compound Parabolic Collector, www.solargenix.com

Solaria. Another Silicon Valley startup with \$22 million in venture capital.

Solaris Technologies LLC

SolarWorld Industries America, headquartered in Bonn, Germany, purchased

Shell Solar's crystalline silicon activities in 2006.

Solec International Inc. (part of Sanyo), 970 East 236th Street, Carson, California 90745. E-mail: solec@solecintl.com

Solel. The Israeli company has helped to build and maintain the largest commercial solar power plant in California.

Solems SA. 3, rue Léon, Blum Zone d'Activité "Les Glaises" 91124 Palaiseau Cedex, France. Tel: 33 1 69 19 43 40.
E-mail: info@solems.com.

SolFocus is a Silicon Valley startup with initial funding of \$25 million to develop solar concentrators.

Solmecs (Israel) Ltd, Omer Industrial Park, P.O. Box 3026, Omer 84965, Israel. Tel: 972 7 6900950.
E-mail: michael@solmecs.co.il

Solterra Fotovoltaico SA. via Milano 7, CH - 6830 Chiasso, Switzerland. Tel: 41 91 695 40 60. E-mail: info@solterra.ch

Solucar. An affiliate of Abengoa, the Spanish-based diversified energy company. www.solucar.es

Sopogy. Produces a MicroCSP collector that produces 500 watts, roughly what a house consumes.

Spectrolab, 12500 Gladstone Avenue, Sylmar, CA 91342. Tel: (818) 365-4611. Boeing subsidiary.

Stirling Energy Systems Inc., Biltmore Lakes Corporate Center, 2920 E. Camelback Road, Suite 150, Phoenix, Ariz. 85016. Tel: 602 957 1818
E-mail: ses@stirlingenergy.com. Solar.

SunPower Corp., 3939 N. 1st St., San Jose, CA 95134. Tel: (408) 240-5500. Subsidiary of Cypress Semiconductor. SunPower Corporation designs and manufactures high-efficiency silicon solar cells and solar panels based on an all-back-contact "All-Black" design. They install them through subsidiary PowerLight. Recent projects include large PV installation at Nellis Air Force base, Nev.

Suntech Power Holdings Co. Ltd., 17-6 ChangJiang South Road, New District Wuxi, China 214028. Tel: 86 510 5345000. E-mail: sales@suntech-power.com. One of China's leading entrepreneurial businesses in the renewable energy field. The world's third largest maker of solar cells.

Sunways AG, Macairestr. 3-5, 78467 Konstanz, Germany. Tel: 49 7531 99677-0

Superprotonic, backed by San Francisco-based Nth Power, is commercializing solid-acid fuel cells for cars. Depending on what power source it's replacing, storage is predicted to be at least a \$12 billion market by the end of the decade.

Tata/BP Solar (JV between BP Solar/Tata), #78, Electronic City, Hosur Road, Bangalore, 560 100 India. E-mail: tata@tatapb.com

TerraSolar Inc., 44 Court St., Tower B, Brooklyn, NY 11201. E-mail: info@terrasolar.com

TekSun PV Mfg. Inc., Austin, TX.

Tianjin Jinneng Solar Cell Co. Ltd., Tianjin High Tech Industrial Park, Chinese Catalpa Park Road 20, Tianjin, 300384 PR China. Tel: 86 022 23078366. E-mail: postmaster@jns.cn

Topraysolar raised about \$60 million in its IPO. Chinese investors.

Torresol Energy. A joint venture of Spanish engineering firm Sener and Abu Dhabi firm Masdar.

Trina Solar, 13505 Oregon Flat Trail, Austin, TX 78727. A pioneering PV firm based in China. Has installed 39 solar power systems at sites in Tibet.

UPV Solar, Coimbatore, Tamil Nadu, India

Udhaya Semiconductors Ltd., 1/482, Avinashi Road, Neelambur, Coimbatore 641 014, India. E-mail: udaya@uslsolar.com

Udhaya Energy Photovoltaics Pvt Ltd (UPV Solar). 1/279Z Mudalipalayam, Arasur Post, Coimbatore, Tamil Nadu 641 407.

India. +914222361170. info@upvsolar.com. Has new plant at Mudalipalayam, about nine miles (15 km) east of Coimbatore.

United Solar Ovonic, 3800 Lapeer Road, Auburn Hills, MI 48326, Tel: 1 248 475 0100. E-mail: info@uni-solar.com. A wholly owned subsidiary of Energy Conversion Devices. Currently employs 700 people.

Usha India Ltd., 12/1, Mathura Road Faridabad Haryana, 121 003, India. E-mail: sales@uslsolar.com

USL Photovoltaics Private Ltd., 1/473 Avinashi Road, Neeambur, Coimbatore - 641 014, Tamil Nadu, India. Tel: 91 422 2627 851

VHF-Technologies SA., Av. des Sports 18, CH-1400 Yverdon-les-Bains, Switzerland. E-mail: marketing@flexcell.ch

Viva Solar Inc., P.O. Box 53004, 10 Royal Orchard Blvd, Thornhill, Ontario L3T 7R9, Canada. E-mail: sales@vivasolar.com.

West Bengal Electronics Industry Development Corporation Limited (Webel SL Solar), Plot No. NI, Block GP, Sector V, Salt Lake Electronics Complex, Kolkata - 700 091, India. Tel: 91 33 2357 8840. E-mail: info@webelsolar.com

Wurth Solar, Ludwigsburger Strasse 100, 71672 Marbach an Neckar, Germany. E-mail: wuerth.solar@we-online.de

Yingli Green Energy, No. 3055 Fuxing Middle Rd., National New & High-Tech Industrial Development Zone, Baoding, China P.C.: 071051. Tel: (86) 312-892 9700. One of the largest manufacturers of PV products in China. E-mail: yingli@yinglisolar.com

Yunnan Semiconductor, Jianshe Road, 295 Kunming, Yunnan, China. Tel: 86 871 538 9169. E-mail: greenstar@km169.net

Zhejiang Sunflower Light Energy Science & Technology Co. Ltd., Zhanjiang Road, Paoting Industrial Zone, Shoaling, Zhejiang, China. E-mail: yujing2062@163.com

5. Water Energy Industries

Water energy surges forward as an exciting source of alternate power. New technology promises to utilize a resource that is plentiful, cheap, and – renewable – with no emissions. In systems that show promise, electric generators are being driven by tidal action, wave motion, stream currents and/or heat transfer.

Jobs! Energy!

I have never met Kenichi Horie, but I am one of his enthusiastic admirers. In my opinion he is one of the world's boldest and most creative futurists. In 1962, when he was 23 years old, he sailed a small yacht solo across the Pacific from Japan to San Francisco. In later years he honed his sailing skills with solo nonstop voyages around the world.

To explore new concepts Kenichi sailed a solar-powered boat from Hawaii to Japan, again solo. That was followed by an incredible solo voyage from Hawaii to Japan on a small pedal-powered boat. Yes, pedal-powered!

During his lonely months at sea, Kenichi had a lot of time to observe the relentless energy of ocean waves. At the same time he watched dolphins glide alongside by simply moving their tails to gain forward thrust. He pondered how he could propel his boat so effortlessly and dreamed of a system that required no physical effort, used no fuel and created no pollution. Experts agreed that this was impossible. Throughout the history of mankind, nobody had ever developed any such marvelous invention.

By 2007, Kenichi had achieved the impossible – a system of propelling his boat using power captured from ocean waves. His invention absorbs energy from incoming waves and through linkages and springs uses that energy to move paddles creating a propulsive force like that of the dolphins. Kenichi has proven all of the experts wrong by making demonstration runs around Osaka Bay in his wave-powered *Suntory Mermaid II* catamaran. A voyage from Hawaii to Japan will soon get the world's attention.

There is a powerful lesson here for every energy user. While the world struggles to keep up with its enormous appetite for fuel, we are overlooking solutions right before our eyes. What Kenichi has done is just part of a new era of ocean energy utilization.

One of many breakthroughs!

Spurred by economic and environmental pressures, there are scores of significant new projects around the world that involve new technology and creative investment. We are witnessing the rapid emergence of a new mix of ocean energy projects that will

soon join the wind, solar, and other alternate energy ventures already in operation.

The oldest and largest renewable energy source is *hydro*. The big dams and integrated generating units produce electric power measured in thousands of megawatts. The new Three Gorges project in China is rated at 22,500 MW, eclipsing the Iguazu installation in South America and the James River complex in Canada.

Ocean energy has special appeal because the basic economics look so good. Water is more than 800 times as dense as air and thus represents a very concentrated form of energy as compared with wind. Ocean energy systems should also be less vulnerable to interruptions than those dependent on wind or sunshine.

Ocean energy developments fall into four groups that seek to capture different forms of energy:

- *Wave* energy – a variety of units that capture energy from the motion of individual ocean waves.
- *Stream* energy – units with underwater turbines located in powerful ocean currents.
- *Tidal* energy – hydro units with low dams or barrages situated where tides are very high.
- *Thermal* energy – heat transfer units that utilize the difference in the temperature between surface water and deep ocean water.

Each of these developments poses plusses and minuses. Of course, large ocean energy projects will bring questions about impact on the environment. For most projects, however, it appears that environmental conflicts can be managed. Let's take a quick look at each of them.

Of all types of ocean energy, wave energy is the one that appears to be ready to break through and open the door to almost unlimited possibilities today. Opportunities range across the board from small simple units for remote islands to large arrays of highly sophisticated systems to serve population centers.

Waves are found everywhere that there is an ocean. Their strength is influenced by the moon, surface winds and other factors. I well remember while crossing the Drake Passage between Cape Horn and Antarctica several years ago, the waves at times were higher than the ship I was on.

The north and south temperate zones with their prevailing westerlies may have the best sites for capturing wave power. However, I can personally attest to the availability of waves almost everywhere. I have walked along beaches in Antarctica, the Caribbean islands, Florida, California, Mexico, Arabian Gulf, Guam, New Zealand, Australia, Thailand, Fiji, Hawaii, Palau, Seychelles, Nice, Djerba, and Beirut, to name a few, and have not seen a shore without wave energy.

Some simple wave-capture machines float on the surface. Others are anchored to the sea bed where they are

out of sight and less vulnerable to storms. The many varieties already put forward include flappers or pumps that are vertical or horizontal. Some involve underwater turbines. Others pump seawater ashore to either a turbine to produce electricity, or to a reverse osmosis filter to produce fresh water.

A free-for-all competition to capture this new market is already underway. Several of the world's biggest corporations with astute science staffs have entered the fray and begun deploying working machines. Among them are:

“Pelamis” machine made by Pelamis Wave Power Ltd. (formerly Ocean Power Delivery). The first commercial wave farm using Pelamis machines began operation in 2006 off the coast of Portugal. Another is being developed off the coast of Scotland. Other projects are in the planning stage. GE is an investor.



The Pelamis machine has a series of semi-submerged sections connected by hinged joints. Motion caused by waves is transmitted to hydraulic pumps that push oil through motors that drive electric generators. The typical output is 750 kW per machine. An undersea cable takes power to shore.

The Pelamis is designed to convert only a portion of the energy in a wave rather than absorb all of the wave energy, enabling it to ride out heavy storms. Lying on the surface it looks somewhat like a big snake.

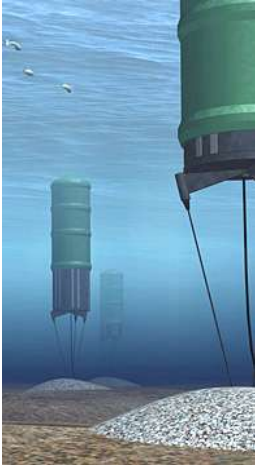
Another invention is the “Wavegen Limpet” machine product of Voith Siemens Hydro. A Limpet plant installed on the island of Islay, off the west coast of Scotland, in 2000 is claimed to be the world's first grid-connected commercial-scale wave energy unit. The original developer Wavegen has since been acquired by Voith Siemens Hydro.



Wavegen is a shoreline, wave energy converter using an inclined oscillating water column (OWC) built into a cliff. It has a Wells turbine power take-off. Advantages claimed are easy access and maintenance, proximity to grid connections, and simplicity. The Wells turbine has no gearbox or hydraulics and handles variable bi-directional flow.

Yet another creation is the “Archimedes Wave Swing” machine from AWS. This is said to be the world's first submerged wave energy system. The concept was proved in full-scale in 2004 via a pilot plant off the coast of Portugal. The Scottish Government has made a multi-million dollar grant to facilitate the commercial development and deployment of the machine. Also participating is Shell

Technology Ventures Fund, an affiliate of Royal Dutch Shell.



The AWS wave energy converter is a cylinder shaped buoy moored to the seabed. Passing waves move an air-filled upper casing against a lower fixed cylinder, with up and down movement converted into electricity. The device is basically simple with only one main moving part. Developers claim that the underwater machines can survive violent storms and produce more power in less space than other wave generation systems.

Stream energy

The Egyptians and Chinese developed water wheels to grind their grain 2,000 years ago. A bit later water wheels were installed throughout the Roman Empire. Thousands of water wheel power units sprang up in England long before the steam engine appeared.

Soon after launching the settlement at Jamestown in 1607, the Virginia Company began building water mills using skills brought from Europe. The practice spread and by 1650 the Massachusetts colony could boast of having mills for grinding grain, running sawmills and powering an iron factory. During the 1700s mills were built throughout the colonies.

In 1840 a man named Samuel Fitz of Hanover, Penn., began manufacturing metal water wheels. He sold more than 1,000 units in Pennsylvania and over 700 in Virginia. Water wheels were an accepted community fixture for many years. As late as the 1920s I remember going with my Dad to a water-driven grist mill near our home in Hackleburg, Ala., to get our corn ground into meal.

At the same time, water wheels powered the industrial development of New England and the textile mills of the South. Mill sites were at the top of the site selection checklist for corporate facility planners. We recite this bit of history to remind that there was a long period when the nation depended on river stream energy.

Back to the future! Today the water wheel industry is making a big comeback in many less-developed parts of the world. Hundreds of new manufactured, small water wheel turbine units are being installed at remote sites where there is a small river or creek flowing year-round.

These small, stream units are obviously important to people who live in areas not linked to a grid. However the big excitement is being caused by new projects that promise to harness the stream energy of the oceans. The prize is infinitely bigger and the simple water wheels have evolved into much more sophisticated systems called turbine power units.

The new turbines are not to be confused with the multi-bladed turbines that power jet airplanes. Those operate at very high temperatures and

spin at several thousand revolutions per minute. The underwater turbines are more like the big fans seen at wind energy farms. They usually consist of two or three propeller blades turning very slowly.

Future undersea turbines will probably be rated at around 1,000 kW each, and will be located in “farms” somewhat similar to present-day wind farms – but less noisy and out of sight. A large array of them could meet power needs on a grand scale. That is the possibility that is intriguing global strategists.

Around the world planners are looking at ocean streams known to exist at such prime locations as the Strait of Gibraltar, the Bosphorus in Turkey, the Torres Strait off Australia, the Strait of Malacca between Indonesia and Singapore, and the Cook Strait in New Zealand. Experiments have already been conducted in the Strait of Messina between mainland Italy and Sicily. Another experimental project seeks to capture energy from the Gulf Stream off the coast of Florida.

The big ocean stream projects are going to be expensive and complex. It will take another 10 years to get them in operation and have a significant impact on world energy needs.

Thermal energy

Ocean thermal energy conversion (OTEC) is a method for generating electricity using the temperature difference that exists between deep and shallow ocean waters. The technology received considerable attention in the 1980s and several projects were

launched. Japanese interests, led by Tokyo Electric, undertook a project at Nauru in the central Pacific and the United States set up a facility at Kona on the big island of Hawaii.

I was intrigued by these efforts and made a trip to both sites. At Kona I learned that the cold water from 3,000 feet (914 m) below the surface not only provided a temperature differential but also brought up rare marine organisms of interest. It appeared that OTEC projects might pop up at a number of island sites from Puerto Rico to Guam and Samoa.

Unfortunately this enthusiasm was dampened by Pacific storms that knocked out the pioneering installations. OTEC systems must of necessity extend a very long pipe down to deep water, and they are vulnerable to damage from rough seas. In view of this it is our guess that other types of ocean energy will be preferred.

Tidal energy

Projects using tidal flows have intermittent input but otherwise resemble existing hydro installations in that they involve low dams or barrages. These are built at sites where the differences between low and high tides are great – say 15 to 20 feet (4.6 to 6 m). At high tide, sea water is allowed to flow into a basin, then barrage gates are closed to hold the water. At low tide the water is then released to flow back through turbines that drive electric generators.

The first large-scale tidal power plant was built at La Rance in France some 40 years ago and has performed well. The first such plant in North America

was developed at Annapolis Royale, on the Bay of Fundy in Nova Scotia. I visited that plant soon after it opened in the 1980s.

Today there are a number of new tidal projects in various stages of development around the world. Some are experimental or pilot projects, but others are already delivering power.

New tidal units face serious environmental resistance. Some of the

same objections that have been raised regarding dams also are found where low-level barrages are proposed. The holding basins inundate mud flats that are the habitats of wading birds and other flora and fauna. Opponents argue that the projects would increase coastal erosion in some areas while causing more silting in others. At this point many big tidal projects are being proposed, but few are receiving permits.

Alphabetical Index of Companies Involved in Ocean Energy

Applied Technologies Company Ltd: 16/10 – 301, Profsoyuznaya ul., Moscow, 117292, Russia. Tel./Fax: +7 (495) 125 2225. An offshore Float Wave Electric Power Station (FWEPS) and installation for Hydrogen Production by means of seawater electrolysis. System's components are in the development stage now.

AquaEnergy Group Ltd (USA): Has been acquired by Finavera Renewables Ltd.

Aquamarine Power: 10 Saint Andrew Square, Edinburgh EH2 2AF, Scotland. "Oyster" is fixed to the seabed and swings back and forth with each wave. This motion captures energy and pumps high pressure water to onshore hydroelectric equipment. Technology from Queens College, Belfast.

AW-Energy (www.aw-energy.com), **AW-Energy Oy:** Lars Sonckin kaari 16 (Terra Building), FI-02600, Espoo, Finland. Tel/Fax: +358 9 7262404. Developer of "WaveRoller."

AWS Ocean Energy, AWS Ocean Energy Ltd: Redshank House, Alness Point Business Park, Alness, Ross-shire, IV17 0UP, Scotland. "Archimedes Wave Swing." An investor is Royal Dutch Shell.

Balkee Tide and Wave Electricity Generator. Raj Balkee, Plateau Road, Goodlands, Mauritius. Tel: +230 2838764

BioPower Systems Pty. Ltd: Suite 145, National Innovation Centre, Australian Technology Park, Eveleigh, NSW 1430, Australia. Has \$10 million funding for wave power projects in Tasmania.

Blue Energy Canada Inc: 1950 West Broadway, Vancouver, B.C. V6J5C2. Developing the "Blue Energy Ocean Turbine."

Bourne Energy: Box 2761, Malibu, CA 90256. Starting to develop "OceanStar, TidalStar and RiverStar" ocean energy recovery units.

Caithness Corporation: Headquarters, 565 Fifth Avenue, 29th Floor, NY, NY. Development, acquisition, operation, and management of geothermal, hydroelectric, wind, and solar energy power projects.

Canoe Pass Tidal Energy Corporation: Campbell River, B.C., Canada. Developing tidal-current energy project in Canoe Pass, which runs between Quadra and Maude islands on B.C. coast – in cooperation with a Calgary-based company called New Energy Corporation Inc. and Focus Environmental.

Carnegie Corporation Ltd: 35 Outram Street, 2nd Floor, Western Australia, West Perth 6005, Australia. Tel: 61/08 9321-6881. Has received \$15 million funding to develop its CETO Wave Energy.

Chevron California Renewable Energy Inc: subsidiary of Chevron Corporation. Researching opportunities in ocean energy.

Clearpower Technology Ltd: Northern Ireland Science Park, Queen's Road, Belfast BT3 9DT. Developer of "Wavebob."

Clean Current Power Systems Inc.: 405 - 750 West Pender St., Vancouver, British Columbia, Canada V6C 2T7. Tel: (604) 602-1222. Manufacturer of turbines for tidal energy systems.

Compagnie Nationale du Rhone, 2 rue Andre Bonin, 69316 Lyon, Cedex 04, France. Develops hydroelectricity from the Rhone and its riparian areas between Switzerland and the Mediterranean. 1,000+ employees.

Crest Energy Ltd: 5th Floor, Ballantyne House, 101 Customs Street, East Auckland, PO Box 105774, Auckland 1143, New Zealand. Proposes to build a 200-MW tidal power plant in the mouth of Kaipara Harbour in northern New Zealand.

C-Wave Ltd: SETsquared, Southampton Building, 27 University of Southampton, Highfield SO17 1BJ, UK.

Daedalus Informatics Ltd: Ikarias 22, Glyfada, Athens, Greece. Hybrid wave and wind system.

Daversen Hydro Power Inc: Redcross Bhavan, 2nd Floor, The Mall, Ludhiana, Punjab 141001, India.

Delaware Technical & Community College, Owens Campus–Georgetown, DE 19947. "Delbuoy" wave powered desalination

De Li Power Industries Ltd: Lian-Hu 2nd Industrial Park, Tang-Xia Town, Dong-Guan 523712, Guang-Dong Province, China, Dong-Guan, Guang-Dong, China 523712. Energy system components.

Dexa Wave Energy Co. UK. Dexa is developing Ocean Wave Energy converters based on Plane Angular Modulation (PAM). Two planes or pontoons float in the waves and change angles relative to each other. The tilt action creates oil pressure in a hydraulic cylinder to drive a hydraulic motor and generator to produce electricity.

Ecofys: P.O. Box 8408, NL-3503 RK Utrecht, The Netherlands. 150 employees in six countries. Danish partner is Eric Rossen. Testing "Wave Rotor" at Nissum Bredning fjord on the northwest coast of Denmark, where the Folkecenter for Renewable Energy manages a dedicated wave energy test site. (See *Wave Star Energy listing*.)

Embley Energy: Oakleigh, Tockington Park Lane, Almondsbury, Bristol BS32 4JE, UK. Developer of "SPERBOY" floating wave energy converter.

EMU Consult, Copenhagen, Denmark. Developing "Wave Dragon" floating offshore wave energy converter, invented by Danish engineer Erik Friis-Madsen.

Engineering Business Ltd: Broomhaugh House, Riding Mill, Northumberland NE44 6EG, England. Has developed "Stingray" tidal stream device. A prototype was installed in Scotland's Yell Sound.

Entec AG: Bahnhofstrasse 4, St Gallen CH-9000, Switzerland. Hydro projects in Indonesia, Laos, Malaysia, Nepal, Tajikistan, Thailand.

Evans Engineering Ltd: Langley Court, Langley Road, Burscough Industrial Estate, Ormskirk, Lancashire, L40 8JR, United

Kingdom. Micro-hydroelectric units for rural sites.

Finavera Renewables Inc: 595 Burrard Street, Suite 3113, PO Box 49071, Vancouver, BC V7X 1G4, Canada. Has started wave projects in Washington State and Oregon as well as Portugal, Canada and South Africa.

Fred Olsen Energy ASA: Oslo, Norway. Shipping magnate Fred Olsen is promoting his “Buldra” wave converter that is situated on an offshore platform built of fiberglass.

GE Energy, a subsidiary of General Electric, is based at 4200 Wildwood Parkway, Atlanta, GA 30339. General Electric’s Technology Lending unit has extended a loan of \$2.6 million to Ocean Power Delivery for its Portugal wave energy farm. Also, GE will take an equity position as part of OPD’s \$22.5 million program.

Generic Wave Energy Device – GWED: Causewayside, Glenaldie, Tain, Scotland, UK IV19 1NE. Tel: +44 1862 892777.

Green Ocean Energy Ltd: 29 Abbotshall Crescent, Cults, Aberdeen AB15 9JQ, Scotland. Developer of “Wave Treader” wave energy converter.

Grupo Insolar SA de CV (former EcoVertice): Calle 82, Lote 17, Mza. 83, Region 233, Cancún, Q. Roo, Mexico 77510. Marine buoy lights.

GuglerWater Turbines: Schaunberg Str.23. 4081, Hartkirchen, Austria

Hydam Technology Ltd: 1, Bishops Court, New Street, Killarney, County Kerry, Ireland. U.S. Tel: (353) 6434 624. Developer of the “McCabe Wave Pump,” a three-barge, floating wave-energy conversion unit for supplying potable water and for irrigation purposes in remote communities.

Iberdrola S.A: 8 Cardenal Gardoqui, 48008 Bilbao, Vizcaya, Spain. Large electric utility. Affiliate Iberdrola Energias Marinas de Cantabria, S.A. Contracted with Ocean Powers Technologies Ltd. of U.S. for development of a wave energy plant at Punta del Pescador, Santoña, Spain.

Independent Natural Resources Inc. 7466 Washington Avenue South Eden Prairie, MN 55344. The system is designed to generate electricity and desalt seawater.

Inter-American Investment Corporation: 1300 New York Avenue NW, Washington DC 20577. Has made equity investment in C to C Holdings Ltd, a company that will develop and deploy a series of Submersible Power Generators (SPGs) to generate electricity utilizing the flow of ocean and/or tidal currents. Guatemala.

Interproject Service AB: Gripensnäs, S-640 33 Bettna, Sweden. Promoting “OWEC Buoy;” AquaEnergy is the intellectual property successor.

IT Power Ltd: Grove House, Chineham Court, Lutyens Close, Chineham, Basingstoke, Hampshire RG24 8AG, UK. The company is leading a \$2 million research and development project on a tidal stream energy device, “Pulse Stream 100.”

Lion Energy S.A.: 7A Pedelis Avenue, Athens, Greece 15235. Hydroelectric turbines.

Marine Current Turbines Ltd: The Court, The Green, Stoke Gifford, Bristol, BS34 8PD, UK. Has installed its “SeaGen” tidal energy system off the northern coast of Ireland.

Nam Nhone Hydropower Co. Ltd: P.O. Box 11544, House 50, Unit 05, Ban Sokpaluang, Sisatanak District, 21000 Vientiane, Lao PDR. A Lao-French (30%-70%) joint-venture. Building a \$4 million hydro power plant in Tonpheung district.

Neptune Marine Services Ltd (Neptune Renewable Energy): 18 High Street, North Ferriby, East Yorkshire HU14 3JP. Has acquired Aberdeen-based Ross Deeptech Initiatives Ltd. Tidal energy systems and the Neptune “Triton.”

New Energy Corporation Inc.: 3553 – 31st Street NW, Suite 473, Calgary, AB T2L 2K7, Canada. Tel: (403) 260-5248. Vertical-axis turbine for underwater use.

Oceanlinx Inc . (formerly Energetech Australia Pty Ltd) (www.oceanlinx.com): PO

Box 116, Botany, NSW 1455, Australia. Tel: 61 2 9549 6300; Fax: 61 2 9549 6399. Developed the Energetech Wave Energy System, a shoreline device. Oceanlinx has projects under development in Australia at Port Kembla in New South Wales, Portland in Victoria, and King Island in Tasmania; and internationally in Rhode Island and Hawaii in the U.S.; South Africa; Mexico; and the U.K.

Ocean Navitas Ltd: Nursery House, Mar-ton, Lincolnshire, UK DN21 5BQ. Using the facilities at the New and Renewable Energy Centre in Blyth, Northumberland, for testing 2 kW prototype “Aegir Dynamo” wave energy converter.

Ocean Power Technologies Inc.: 1590 Reed Road, Pennington, NJ 08534. Plans to install a 5 MW “Powerbuoy Smart System” project for the U.S. Navy in Oahu, HI. Ocean trials have also been conducted off the coast of New Jersey. OPT is installing a wave farm off the northern coast of Spain in cooperation with the Spanish utility Iberdrola SA. Another full-size demonstration plant is planned for UK waters.

Ocean Prospect Ltd, subsidiary of the Wind Prospect Group: 7 Berkeley Square, Clifton, Bristol BS8 1HG, UK. Firm has agreement with E.ON UK, the country’s largest integrated energy company, to develop a wave energy project off the North Cornwall coast. The project, to be known as WestWave, is a proposed 5.25-MW wave power generating scheme consisting of seven Pelamis P750 machines, manufactured by Ocean Power Delivery.

Ocean Renewable Power Co. LLC: 151 Martine St., Fall River, MA 02723. Has permits for a test of its tidal power system at a site in Maine.

Ocean WaveMaster Ltd: 1 Echo Street, Manchester M1 7DP. UK. Other organizations involved in the project: UMITEK; New and Renewable Energy Centre (NaREC); and University of Manchester, Institute of Science and Technology (UMIST).

Offshore Wave Energy Ltd OWEL (www.owel.co.uk). Floating offshore wave energy.

Open Hydro: 66 Fitzwilliam Square, Dublin 2, Ireland. Firm has developed Open-Centre Turbine technology that is operating at the European Marine Energy Centre in Orkney, Scotland. Nova Scotia Power, an Emera Inc. company, selected Open Hydro’s Open-Centre Turbine in 2007 for a tidal energy project in the Bay of Fundy.

ORECon Ltd: A spin-out company from the University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK. Has raised \$24 million venture capital to build full-scale wave converter.

Pacific Gas & Electric: 1 Market Spear Tower, Ste. 2400, San Francisco, CA 94105-1126. Tel: 415-267-7000. Has signed contract for wave power installation off Humboldt County.

Pelamis Wave Power Ltd (formerly known as Ocean Power Delivery): 104 Commercial St., EH6 6NF Edinburgh, UK. Tel: +44 131 554 8444. Developer of Pelamis wave converter. GE is an investor.

Renewable Energy Holdings: Adam House, 7 - 10 Adam Street, The Strand, London WC2N 6AA, UK. Investing \$6 million in a commercial prototype of its wave power generator, after successful trials off the Western Australian coast.

SARA Inc.: 6300 Gateway Drive, Cypress, CA 90630-4844. Tel: (714) 224-4410. Is promoting an ocean wave-powered electric (OWEC) generator.

SDE Wave Energy Ltd: 15A Lubetkin St., Tel Aviv, Israel 67532. Tel: 03-7397107. Technology for producing energy from sea waves in conjunction with desalination.

Seabased AB: Midskeppsgatan 24, 120 66 Stockholm, Sweden. Develops industrial solutions for sustainable conversion of ocean waves.

Seapower Pacific Pty Ltd, a joint venture of Pacific Hydro and Carnegie Corporation. Developing CETO wave power converter. Undergoing tests at Freemantle, Western Australia.

Sea Power International AB: Essinge-ringen 72C, Stockholm, Sweden S-11264.

Tel: +46 8 6579551. Developer of wave and tidal current energy.

SEEWEC Consortium (Sustainable Economically Efficient Wave Energy Converter). Eleven participants from six European nations. Developing “FO3” floating wave energy converter previously known as “Buldra.”

Segen Ltd .: Wesley Hall, Queens Road, GB, GU11 3JD; UK. Tel: 0845 084 2445. Has acquired Hydro Generation Ltd. The UK has thousands of old mill sites waiting to be re-activated using modern micro-hydro water turbines rather than water wheels.

SeWave Ltd.: SEV and Wavegen have founded this joint venture to develop a wave energy plant in the Faeroe Islands

SMD Hydrovision, Wincomblee Rd., Newcastle Upon Tyne, NE6 3QS, UK. The company has developed the “TideEl” tidal stream generator and is planning to build the first plant off the coast of Wales, near Swansea. Tidal Electric has also signed an agreement with the Chinese government to develop a 300-MW offshore tidal lagoon near the mouth of the Yalu River

SRI International/SRI Inc. is testing a buoy with “artificial muscle” technology in the waters off St. Petersburg, FL.

Stellenbosch Wave Energy Converter project, South Africa

SyncWave Energy Inc.: Box 459, 1422 Collins Rd., Pemberton, BC, Canada V0N 2L0. The SyncWave™ Power Resonator technology is undergoing prototyping in preparation for commercialization.

Tidal Electric: 50 Albemarle St., 3rd Floor, London W1S 4BD, UK. Is proposing a tidal energy plant at Swansea.

Tidal Generation Ltd: University Gate East, Park Row, Bristol BS1 5UB, UK. Firm is developing underwater turbine.

UEK: PO Box 3124, Annapolis, MD 21403. Tel: (410) 267-6507. Manufacturer of turbines for tidal energy systems.

University of Manchester Intellectual Property Ltd: Manchester, UK. Developer of the Manchester “Bobber” wave converter.

Voith Siemens Hydro Power Generation GmbH & Co. KG: Alexanderstraße 11, 89522 Heidenheim, Germany. Tel: +49 7321 37-6848. Firm has undertaken a tidal current plant in the South Korean province of Wando. Has acquired Wavegen.

Waveberg Development Ltd: 73 West 47th Street, New York, NY 10036. Developing wave energy converter.

Wave Dragon ApS, Blegdamsvej 4, DK-2200 Copenhagen N, Denmark, Phone: + 45 3536 0219. Developing “Wave Dragon” for large-scale ocean energy systems.

WAVEenergy AS: Company based at Aalgard, 12 miles (20 km) south of Stavanger, Norway. Founded in 2004 to develop the Seawave Slot-Cone generator (SSG) concept.

Wavegen (acquired by Voith Siemens Hydro). “Limpet” (Land Installed Marine Powered Energy Transformer). The current Limpet device, Limpet 500, is located on the island of Islay, off Scotland’s West coast. It was installed in 2000 and produces power for the national grid.

Wave Energy Technologies – Wave Energy Technology, Nova Scotia. Developing a wave converter – “WET EnGen” converts ocean energy into mechanical energy to produce electricity, and/or desalinated water.

Wavemill Energy Corporation, 1 Research Drive, Dartmouth, Nova Scotia, B2Y 4M9 Canada.

Wave Star Energy, Maglemosevej 61. 2920 Charlottenlund, Denmark. Wave Star Energy in scale 1:10 has now been in operation and grid-connected since April 2006 at Nissum Bredning in the northwestern corner of Denmark.

Water Energy Projects Around the World

Australia

Oceanlinx (previously known as Energetech) has installed wave energy projects in New South Wales, Victoria and Tasmania. The International Academy of Science named the **Oceanlinx wave energy device** as one of the ten most outstanding technologies in the world for 2006.

An Australian company, Tidal Energy Pty Ltd, began commercial trials of **shrouded turbines** in Queensland in 2002. The firm proposes turbine installations for locations in Canada, Vietnam and elsewhere.

Seapower Pacific has completed a year-long trial off Fremantle, producing electricity from the 66-ft. (20-m) prototype wave machine called CETO. Future plans are to have 125 CETO units that could produce 18 MW of electricity or 12 billion gallons (45 billion liters) of fresh water. Renewable Energy Holdings PLC said it has deployed its first **CETO II Wave Energy prototype** off Fremantle.

It was announced in 2008 that an Australian ocean energy company, **BioPower Systems Pty Limited**, has been awarded a \$5 million grant under the Australian Government's Renewable Energy Development Initiative (REDI).

Bermuda

The Bermuda Electric Light Company Limited (BELCO) and Current to Current Bermuda Ltd. have announced plans to install an **underwater turbine** to produce 10 MW power – about one tenth of the island's total need.

Canada

Canada built a 20-MW **hydro tidal barrage plant** at Annapolis Royale Nova Scotia on the Bay of Fundy in the 1980s. I visited the site soon after it began operating and was impressed with both the facility and the big 20-foot (6-m.) tides that raced across the bay.

British Columbia Tidal Energy Corp. has said it will deploy several **1.2-MW turbines** in or along the coastline of British Columbia by 2009.

The province of New Brunswick in 2005 began studies of the feasibility of installing turbines off the coast to generate electricity.

SyncWave Energy is reported to have undertaken a three-year, \$15 million **demonstration project** off the West Coast of British Columbia.

Finavera Renewables is planning a 5-MW **wave energy project** at Ucluelet, BC. Project participants include Powertech, a division of BC Hydro. Expansion to 100 MW is projected.

Caribbean

Delbuoy located an experimental unit at St. Croix in the U.S. Virgin Islands to **generate power and desalt seawater**. Unfortunately the installation was wrecked by a hurricane.

GenOtec has proposed a design for a 5 MW **OTEC plant** at St Croix. Another OTEC plant was proposed for a site off the northern coast of Puerto Rico, but the project has apparently been abandoned.

China

The Chinese government has signed an agreement with UK-based Tidal Electric for a **tidal barrage power project** near the mouth of the Yalu River. The proposed 300-MW plant would be the biggest one of its type in the world. The Chinese government is also planning a number of other smaller plants.

Denmark

Wave Star Energy is reported to have installed a unit at Nissum Bredning in north-western Denmark. Officials say the plant has

been connected to the grid for several thousand hours and has survived several storms.

France

The 240-MW La Rance power station near St. Malo, Brittany, in France that began operation in 1966 was the world's first significant **tidal power installation**. It has given good service for more than 40 years providing power for 240,000 homes. It is said to generate power at 3.7 cents per kW hour as compared with nuclear plants at 3.8 cents and thermal plants at 10.5 cents.

Ocean Power Technologies, a U.S. company, is reported to be studying sites along the French coast for a 5-MW **wave power station**. Also interested in the venture are Total Energie Developpement SAS, a unit of Total SA, and Iberdrola SA.

India

In 2003 it was reported that a 1-MW, floating **OTEC power plant** was in the final stages of commissioning near Tuticorin port.

India sources report that National Hydro-electric Power Corporation (NHPC) and West Bengal Renewable Energy Development Agency (WBREDA) will launch a **tidal power plant** on Durgaduani Creek near Gosaba to be in operation by 2010. Another Indian **tidal project** will be situated at Kutch in Gujarat.

The state government of Maharashtra and Apar Urja Pvt Ltd are said to be planning a 15-kW **pilot tidal plant** that, if successful, will be expanded to 250 kW.

The National Institute of Ocean Technology (NIOT) in Chennai, Madras, has commissioned an **OTEC-powered desalination plant** on Kavaratti Island in the Indian Ocean. The LTTD plant is expected to have a capacity of 26,425 gallons (100,000 liters) per day. NIOT is planning to locate other plants at potential sites where effluent water is available from power plants at relatively high temperatures.

A 100-MW floating **OTEC Sea Solar Power** plant has been proposed for the state of Tamil Nadu.

Regency Power Group has set up small **hydro power generation projects** in Himachal and Uttaranchal.

Indian Ocean

OCEES International Inc. is working with the U.S. Navy on a proposed 13-MW **OTEC plant** on the British-administered island of Diego Garcia in the Indian Ocean. The new plant would replace the current power plant running diesel generators and would also provide 1.25 MGD of potable water to the base.

In the Maldives, ocean energy may be used to provide electric power for a new scheme for habitat restoration called **Mineral Accretion Technology**. Research done at Ihuru Tourist Resort uses low voltage, direct currents to grow reefs.

Indonesia

The government has undertaken an experimental program to develop **micro-hydro power systems** for remote areas. The project serves about 5,000 people in the provinces of Nusa Tenggara Timur and South Sulawesi.

Most emphasis, however, is on the development of **thermal power** that is plentiful in various parts of Indonesia.

Ireland

Ireland is reported to have tested a 400-kW **floating wave device** off the coast of Ireland.

The government has earmarked \$35 million for **ocean energy development projects and wave energy test sites** at Belmullet in County Mayo and Ringaskiddy in County Cork.

Cleanpower Technology, an Irish company, is running a small-scale version of its "**Wavebob**" machine in Spiddal County, Galway. This is expected to lead to a full-scale buoy that produces 1 MW. This is one of **five ocean energy projects** funded by Sustainable Energy Ireland. The group is also investing in "Ocean Energy Buoy," "Open Hydro," "AquaBuoy," and "McCabe Wave Pump."

Italy

Italy is reported to have located a 110-kW **pilot tidal energy plant** in the Straits of Messina.

Japan

Kyushu Electric Co. pioneered a 50-kW **OTEC plant** at Tokunoshima Island in the 1980s.

The Port and Harbor Research Institute of the Ministry of Transport is developing a Caisson-type **Oscillating Water Column** to drive turbines producing 60 kW. Tests have been conducted in the Sea of Japan, near Sakata Port in Yamagata Prefecture.

Takenaka Komuten Co. has developed a **constant-pressure manifold pump coupled to a 30-kW generator**. Tests have been conducted near Kujukuri Beach, Chiba Prefecture.

JAMSTEC, Japan, with funding from the Science and Technology Agency, has developed an offshore floating machine called “**Mighty Whale**.”

Muroran Institute of Technology has developed a “**Pendolor**” device to capture wave action. Tests are being conducted off Muro-ran Port in Hokkaido.

Tohoku Power and Mitsui Engineering and Shipbuilding have collaborated to develop a **water-valve rectifier machine**. A test unit running a 130-kW generator was located in a breakwater serving the Haramachi coal-fired power station in Fukushima Prefecture.

Japan’s National Fisheries University, an independent administrative agency, and Saga University have undertaken studies of the feasibility of an **OTEC power plant** for the island of Okinotorishima.

Korea, South

Korea Water Resources Corp. is funding construction of the **world’s largest tidal power plant** at Ansan City’s Shihwa Lake in Gyeonggi Province. The plant will produce 254,000 kW per hour – meeting the demand of Ansan City’s population of 500,000.

Laos

Nam Nhone Hydropower Company is a Lao-French (30-70 percent) joint-venture. Leader and pioneer in the small hydro development in Laos, NNHPC plans to develop three projects within five years (Nam Nhone, Nam Song 7.5 MW; Nam Long 12 MW). Nam Nhone hydropower project is a small-scale effort located on the Nam Nhone River in Bokeo Province. The 2.4-MW project is expected to generate about 80 percent of the province’s needs in 2008.

Mexico

Oceanlinx, a company formerly known as Energetech, has developed **wave energy** in Mexico.

New Zealand

Crest Energy has undertaken to build a \$400 million, 200-MW **tidal power plant** in the mouth of Kaipara Harbour. It is scheduled for completion in 2011.

Norway

A **prototype generator called TAP-CHAN** was installed on a remote Norwegian island in 1985. A tidal unit featuring a tapered channel, it has been in operation for years.

Enova, a Norwegian foundation, has provided some \$5 million to install a **wave power plant** in the ocean west of Karmøy, Rogaland County.

Hydro Tidal Energy Technology, in collaboration with Statkraft and Marintek is reported to be developing a **tidal power plant** in Kvalsundet Strait outside Tromsø.

Two types of **wave power plants** are being tested at Tostestallen. One uses an **oscillating water column** to drive air through a turbine. The other captures **waves spilling over a dam**.

Pacific Islands

A pioneering **OTEC project** was located at **Nauru** in the Central Pacific. A 100-kW plant sponsored by **Tokyo Electric** began operating in 1981, which I visited soon af-

terward. Unfortunately a passing typhoon knocked the plant out.

The Government of **Palau** in 2008 launched a feasibility study for a \$250 million **OTEC** installation to produce power and desalt sea water. A Palau OTEC project had been planned by Saga University of Japan.

A **wave energy evaluation** program has been conducted by OCEANOR for the South Pacific Applied Geoscience Commission (SOPAC). Data collection buoys were located off shore at Rarotonga in the **Cook Islands**, Kadavu in the **Fiji** group, Tongatapu in the Kingdom of **Tonga**, Funafuti in the **Tuvalu** group, Efate in **Vanuatu** and Upolu in **Western Samoa**.

Oceanlinx Ltd., an Australian company has proposed to build a \$20 million, 2.7-MW, **wave energy generator** off the coast of **Maui**. Maui Electric Company. The project will include three wave platforms and could be operational by the end of 2009.

A 10-MW **OTEC plant** has been proposed for the **Marshall Islands**.

The U.S. Army has issued a request for information for a 13-MW **OTEC plant** for the **Kwajalein Atoll**.

Blue Energy Canada is building a 30-MW '**tidal fence**' off the **Philippines**.

Portugal

What is claimed to be the world's first commercial **wave energy project** is now delivering 2.25 MW off the northern Portugal coast near Aguçadoura. The pioneering installation involves three of Ocean Power Delivery's **Pelamis** machines. An array of some two dozen machines is planned. The project is expected to meet the electricity demand of more than 15,000 Portuguese homes.

Finavera is proposing a 100-MW, **staged-power project** at Figuera da Foz beginning with a 2-MW pilot plant in 2009.

Russia

Russia plans to build a very large **tidal power plant** at Kislogubsk. A pilot, floating

1.5-MW tidal plant has been launched at Severodvinsk, to be installed near the site in the Barents Sea. When the pilot operation is successful, a 10,000-MW station will be built.

Two new **tidal power plants** are planned for construction in the White Sea and the Sea of Okhotsk, with capacities of 10 GW and 20-90 MW.

South Africa

Finavera Renewables is planning a 20-MW, **staged-power project** in South Africa, according to CEO Jason Bak.

Oceanlinx, a company formerly known as Energetech, is developing **wave energy** in South Africa.

Spain

What is said to be the "**first commercial breakwater wave energy plant**" is to be built at Mutriku in Northern Spain on the Atlantic coast for the Basque Energy Board, Ente Vasco de Energia. The installation will feature Voith Siemens Hydro Power Generation's wave equipment, acquired in Siemens' purchase of Wavegen earlier this year. The 300-kW project will involve 16 turbines and a new breakwater.

Sweden

The Swedish utility Vattenfall is investing several million dollars in a **wave power project** planned by Uppsala University scientists. Ten generators are included.

United Kingdom

The European Marine Energy Centre (EMEC), located in Orkney, Scotland, is a world leader in promoting various types of ocean energy. The center recently awarded grants totaling more than \$17 million for nine projects that included: AWS Energy (\$2.7 million) to install a 500-kW "**Archi-medes Wave Swing**" machine; ScotRenewables (\$2.24 million) for a **floating tidal stream energy converter**; OpenHydro (\$1.5 million) for a 250 kW "**open-center turbine**" installation; CRE Energy Ltd (\$5.7 million) for four Ocean Power Delivery Pelamis machines with an output of 3 MW;

Ocean Power Technology (\$.788 million) for a “PowerBuoy”; and smaller projects by Aquamarine, CleanTechCom, Wavegen and Tidal Generation.

During 1999-2006, a commercial-scale 300-kW **underwater turbine** called “**Sea-flow**” was tested off Lynmouth, Devon, by a group including IT Power, Seacore, Kassel University; and Jannel-Kesterman, a specialist in gearbox manufacturing. This is being followed by a project called “**SeaGen**,” implemented by Marine Current Turbines Ltd. MCT is installing a 1.2-MW **tidal turbine** in Northern Ireland. One of the appeals of this system is that the rotors turn at about 15 rpm – much slower than a ship’s propeller – and will not damage fish.

Lunar Energy, a British company, in cooperation with E.On, is building a **tidal energy farm** off St David’s peninsula in Pembrokeshire, Wales. It will employ eight large turbines on the sea bottom.

In the early 1990s the **OSPREY** (Ocean Swell Powered Renewable Energy) project was launched off the coast of Scotland. Unfortunately, Hurricane Felix in 1995 caused the big, 1 MW, commercial unit to sink in the Clyde Estuary.

A project known as “**LIMPET 500**” (Land Installed Marine Powered Energy Transformer), developed by Wavegen, has been located on the island of Islay off Scotland’s west coast, and connected to the national grid. It provides enough power for about 500 homes.

“**SPERBOY™**,” a floating wave energy converter developed by Embley Energy, is being studied for a site at Benbecula in the Outer Hebrides, off the coast of Scotland.

Ocean Power Delivery of Edinburgh is developing their **Pelamis wave power systems**.

Another Scottish firm, AWS Ocean Energy, has gotten backing from the Shell Technology Venture Fund, an affiliate of Royal Dutch Shell, for its underwater wave energy system known as “**Archimedes Wave Swing**.”

Marine Current Turbines is said to be planning a 10-MW **tidal energy farm** off Anglesey, UK, to be operational by 2009.

One of the world’s most highly publicized **tidal power plant** proposals is the **Severn barrage** installation that would be situated in the Mersey estuary. Proponents argue that the project would bring thousands of new jobs to Somerset and South Wales. Opponents say that environmental damage would be intolerable.

United States

One of the most interesting projects today is the plan to locate a **farm of underwater turbines** in the Gulf Stream off the coast of **Florida**. The work got an initial grant of \$5 million from the state in 2006. The state is expected to contribute another \$10 million, and a federal grant of \$12 million is in the mill. Florida Atlantic University’s Ocean Energy Technology lab in Dania Beach, known as Sea Tech has been pushing the project for several years. Participants now include Florida State University and the University of Central Florida and Florida Power and Light Company.

According to proponents, the installation could generate \$4 billion worth of electricity a year, power three million homes and create 35,000 jobs. It would also power a huge seawater desalting plant to relieve water shortages in some Florida areas. Some say the Gulf Stream could produce power equal to six nuclear power stations.

In **New York** a company called Verdant Power has installed an **experimental underwater turbine** in the East River near Roosevelt Island. When their design is perfected they plan to install 300 turbines to capture a total of 10 MW of power – enough to serve 8,000 homes. Promoting the project are New York State Energy Research and Development Authority and Consolidated Edison. The concept is reported to have sprung from research at New York University.

Meanwhile, the Federal Energy Regulatory Commission has issued 58 permits for ocean energy proposals from Anchorage, **Alaska**, to Key Largo, Fla., and another 30 applications are pending. The FERC has received

nearly 20 applications for test permits in **Washington** and **Oregon** alone.

Finavera Renewables has received a permit to plan a **wave energy project** off Northern **California's** Humboldt County. Power produced by the system would be bought by Pacific Gas & Electric. An initial 2-MW plant could be expanded to 100 MW. Operation is expected to begin in 2012.

AquaEnergy Group Ltd, an Ocean Energy division of Finavera Renewables, has applied for a permit for a **Makah Bay Offshore Wave Energy Project**. The 1-MW prototype would be located three miles (4.8 km) from shore in the Olympic Coast Marine Sanctuary in Northwest Washington. It will use "**AquaBuoys**" rated at 250 kW. Participants include the Makah Indian Nation, Clallam County Public Utility District and others.

Finavera Renewables has already installed a 75-foot- (23-m.)-high yellow buoy **wave-energy converter** offshore of the Port of Newport in Oregon.

Oceanlinx filed with FERC for a 15-MW **wave farm** off Florence, Ore., similar to a successful project in Australia at Port Kembla.

Ocean Power Technologies (OPT) is collaborating with Pacific Northwest Generating Cooperative to develop a 2-MW **wave park** offshore Douglas County, Ore. The plan is to install OPT's "**Powerbuoy**" system 2.5 miles (4 km) offshore in about 164 feet (50 m) of water. The output will range from 2 MW to 50 MW. OPT is also proposing a facility off Coos Bay's North Spit.

A dozen **tidal energy projects** are proposed for sites around Puget Sound from Tacoma northward. The most widely discussed project is at **Grays Harbor, Wash.** It is being promoted by the Washington Wave Co., a subsidiary of Puget Sound Tidal Power.

Permits have been granted to study sites in the Cook Inlet, at Resurrection Bay and in the Wrangell Narrows, all in **Alaska**. There is even a serious proposal to capture energy from the tidal flow under the Golden Gate Bridge at San Francisco. The city has

launched a feasibility study to evaluate a 35-MW project proposal.

Hawaii has been the center of pioneering work on **OTEC** systems. Work began after the energy shortage of the 1970s and has continued through several stages. First there were experimental units aboard ships situated near the Big Island of Hawaii. Then a shore-based plant was built at the new Hawaii Ocean Science and Technology Park adjacent to Keahole Airport near Kona. I visited this project in the 1980s.

A lot was learned from the first operational plant that pumped cold water from 2,700 feet (823 m) below the surface. This input was used not only for energy recovery but to take advantage of a variety of unexpected scientific opportunities. When I was there, very pure deep-ocean water was being delivered to park occupants engaged in aquaculture, pharmaceutical and related research, providing an R&D opportunity not found elsewhere. The latest project Natural Energy Laboratory of Hawaii Authority (NELHA) at Kona is a 1-MW OTEC installation.

New England activity

FERC has approved an application from the town of Edgartown to study a **tidal energy project** for Muskeget Channel between Martha's Vineyard and Nantucket.

GreenWave, R.I., has proposed a **pilot wave energy plant** off the coast of Rhode Island. The project is funded by three New England states and is based on research at the University of Rhode Island.

Oceanlinx, formerly known as Energetech, is developing a **wave energy project at Rhode Island**.

The Atlantic Tidal Energy Consortium has announced plans to build a 600-MW **tidal power plant** in the Bay of Fundy.

Elsewhere there is interest in tests in the Gulf of Mexico, off the **Texas** coast, for a new **wave-powered pump system** called "**SEADOG**." It is being developed by Minnesota-based Independent Natural Resources Inc. The system is designed to generate electricity and desalt seawater.

6. Geothermal Energy Industries

Geothermal energy is the third largest source of renewable energy in the United States, behind hydropower and biomass.

Jobs! Energy!

The Department of Energy (DOE) reports that there are now 69 geothermal generating facilities in operation at 18 sites around the country, mostly concentrated in California. By 2005, California's geothermal capacity exceeded that of every country in the world.

These pioneering ventures are the forerunners of hundreds of projects yet to come. DOE official Alexander Karsner points out, "All of the earth underneath the United States has some thermal capacity."

Around the world new technologies are now making it feasible to exploit this resource. Chevron Geothermal Energy, for example, has been developing big projects in Indonesia and the Philippines – enough power for seven million homes. The U.S. Department of Energy has announced it is partnering with Australia and Iceland to develop new enhanced geothermal systems that some advocates claim could one day generate enough power to meet all the world's energy needs.

We have made a good start. The units that have been developed,

sometimes at great expense and effort, have paved the way. Now the time has come to apply what we know to a large number of projects.

Here are some examples provided by the staff of the U.S. Geological Survey and other sources:

California

According to the California Energy Commission, the state has 46 geothermal plants with a total installed electrical capacity of about 2,500 MW. **The Geysers**, operated by Pacific Gas and Electric, is the country's first large-scale, geothermal electricity-generating plant. The first turbine, producing 11 MW of net power, has run successfully for more than 30 years.

The Geysers Geothermal Field has been the world's largest producer of geothermal electrical power since the 1970s. It reached a peak of more than 1,600 MW in 1987. Today, The Geysers' 21 power plants are operated by Calpine Corp. (19 facilities) and the Northern California Power Agency (2 facilities).



Salton Sea (California) Geothermal Plant

Calpine has proposed to build a 49.5-MW power plant in the northwest section of the **Glass Mountain Known Geothermal Resource Area (KGRA)**.

Calpine also plans to build a second 49.5-MW power plant, the **Telephone Flat Project**, in the southeast section of the Glass Mountain KGRA, east of Medicine Lake.

Near Honey Lake, **Amedee** geothermal plant has contributed electricity to the California grid since 1988. **Surprise Valley** also has well-documented potential for geothermal power development, on the order of several tens of MW. The Bonneville Power Administration (BPA, Portland, OR) has expressed interest in geothermal power production from the area.

The **Casa Diablo Geothermal Area** plants on the eastern front of the Sierra Nevada Range generate enough power for approximately 40,000 homes. The power is sold to Southern California Edison.

The **Coso Geothermal Field** is located within the China Lake U.S. Naval Air Weapons Station near Ridgecrest. Power plants in this field are operated by Caithness Energy, of Reno, Nev. More than 100 wells have been drilled throughout the field, with production depths from 2,000 to 12,000 feet (610 to 3,658 m), and temperatures from 392 to 662 F (200 to 350 C).

ORMAT Nevada Inc., Sparks, Nev., has acquired geothermal projects at **East Mesa**. These plants are cur-

rently producing power for sale to Southern California Edison.

Major activity is found in the **Imperial Valley Geothermal Area** near the Salton Sea.

CalEnergy Operating Corp., a subsidiary of MidAmerican Energy Holdings, Omaha, Neb., owns all of the power plants in the **Salton Sea Geothermal Field**, which contains the region's hottest and most saline brines. CalEnergy currently produces over 340 MW from their geothermal power plant Units 1 through 5. CalEnergy plans to increase production by 185 MW with construction of Unit 6, which will be the largest geothermal power plant in the world.

CalEnergy has also built a \$400-million facility to extract up to 27,216 tons (30,000 metric tonnes) of zinc per year from spent geothermal brines at its Salton Sea geothermal power plants.



The Leathers Geothermal Power Plant at Calipatria, Calif.

Hawaii

Currently, Hawaii has one power plant – the **Puna Geothermal Venture (PGV)** operating on the big island of Hawaii. It delivers an average of 25-35 MW of firm energy on a continuous basis, supplying approximately 20 percent of the total electricity needs of the Big Island.

Idaho

In December 2007, U.S. Geothermal Inc. finished construction of the first geothermal power plant in Idaho at **Raft River** and in January 2008 began producing 10 MW – enough electricity to power approximately 2,900 homes. The firm’s schedule calls for increasing to 36 MW within four years, and potentially 90 MW or better in the future.

Nevada

In 2007, Nevada had 16 power plants with a capacity of 301 MW. Together these plants produced a net-total of 1,216 GWh during the year. In 2008, an additional plant, **Galena 3**, went online. This made Nevada’s name-plate capacity approximately 318 MW.

More new plants are under development. Nevada Power Co. will invest in a 30-MW plant near **Fallon** according to an announcement from Sierra Pacific Resources, Nevada Power’s parent company. The utility and Ormat Technologies, a geothermal developer, will each own 50 percent of the **Carson Lake project**, as it is called. Ormat officials said the venture is the first time an investor-owned utility has directly invested in

a geothermal project in the United States.

Other Nevada sites include: Brady Hot Springs, Beowawe, Desert Peak, Dixie Valley, Empire, Soda Lake, Steamboat Hills, Steamboat Springs, Stillwater, and Wabuska.

New Mexico

New Mexico Governor Bill Richardson and Raser Technologies Inc. announced in late August that construction has begun on the first commercial geothermal power plant in New Mexico. Located near **Ani-mas** in the southwest corner of the state, the 10-MW **Lightning Dock** geothermal power plant will produce power using modular “PureCycle” power units from UTC Power, a subsidiary of United Technologies Corporation.

First deployed at Chena Hot Springs Resort near Fairbanks, Alaska, in 2006, the PureCycle units use relatively low-temperature geothermal resources to vaporize an organic fluid, using that vapor to spin a small generator to produce power. According to Raser, 45 PureCycle units will be combined to form the 10-MW plant. The modular, prefabricated system will allow Raser to build the power plant in only six months and easily accommodates Raser’s plans to expand the plant to 20-25 MW eventually.

Utah

While two geothermal power plants operate in southwestern Utah, direct use is more extensive. Eighteen projects use geothermal energy at ten

areas. Greenhouse heating is the largest use, followed by swimming pools. Six resorts use geothermal water for the heating of pools, small space-heating applications, and therapeutic baths.

Commercial greenhouses using thermal water for space heating operate near **Newcastle** in Iron County and at **Crystal Hot Springs** near Bluffdale in Salt Lake County.

Covering more than 24 acres (9.7 hectares), Milgro Nurseries operates

one of the largest **geothermally heated greenhouses** in the country. Milgro produces potted chrysanthemums, Easter lilies, and poinsettias, but also has large Dutch bulb crops, including irises, tulips, daffodils, hyacinths, and potted calla lilies among others. Milgro's main complex and several other commercial greenhouses at Newcastle, covering a total of more than 26 acres (10.5 hectares), use the geothermal fluid from shallow production wells about 500 feet (152 m) deep.

7. Biomass Energy Industries

Using wood wastes, urban garbage, special crops and algae as fuel

Jobs! Energy!

Today biopower ventures range from the mundane to the limits of mankind's imagination. *Wood* is still the largest bioenergy resource available. Wood energy is derived both from direct use of harvested wood as a fuel and from wood waste streams. The largest source of energy from wood is pulping liquor or "black liquor," a waste product from processes of the pulp, paper and paperboard industries.

Urban wastes are the second-largest source of biomass energy. The main contributors are municipal solid wastes and industrial wastes. Other sources include grasses, agricultural residues, manure and methane from landfills.

There are sound reasons why development of new plants using urban wastes as fuel deserves high priority. The average American produces more than 1,600 pounds (726 kg.) of waste a year. We can't keep dumping this waste in landfills. Many communities are already running out of suitable sites for new landfills. And, since most people don't want landfills in their backyards, it has become more difficult to obtain permits to build new landfills.

Further, it is expensive to transport garbage a long distance.

Biodiesel production

Biodiesel is a clean-burning alternative fuel produced from domestic, renewable resources such as new and used vegetable oils and animal fats. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. Biodiesel can be blended at any level with petroleum diesel.

A major hurdle facing commercial biodiesel production is the cost of producing the fuel. Vegetable oil seed procurement, transport, storage and oil extraction accounts for at least 75 percent of the cost of producing biodiesel. The cost varies depending on the feedstock used.

Ethanol production

Ethanol is the most widely used biofuel today. Also known as ethyl alcohol or grain alcohol, it can be used either as an alternative fuel or as an octane-boosting, pollution-reducing additive to gasoline. It is an alcohol fuel made from sugars and starch found in plants. In the United States, ethanol is primarily produced from the starch contained in grains such

as corn, grain sorghum, and wheat through a fermentation and distillation process that converts starch to sugar and then to alcohol.

Currently, most ethanol is made from corn, but new technologies are being developed to make ethanol from other agricultural and forestry resources such as: corn stover (stalks and residues left over after harvest); grain straw; switchgrass; quick growing tree varieties, such as poplar or willow; and municipal wastes.

When the cost of gasoline started shooting up in recent years, plants were set up to produce ethanol from corn. Congress enacted legislation providing a subsidy for corn farmers. That proved to be a mistake – corn prices went up dramatically and that raised the prices of many food items

sold at supermarkets. Energy planners are urging that the corn subsidy be eliminated and that ethanol no longer be made from food stocks.

Florida site factors

Because of its high water table, Florida has a stronger incentive than most states to find alternatives to putting solid wastes in landfills. Some Florida coastal counties even have landfills that begin at ground level and rise as high as 200 feet (61 m). State legislation and incentive programs since the 1970s have caused Florida to have the largest capacity of waste-to-energy (WTE) facilities of any state. Not counting the new Ridge Generating Station, there are 12 WTE plants in Florida with a combined capacity of 486 MW.



*Lake County, Fla., WTE plant
(photo courtesy of National Energy Production Corporation)*

Texas bioenergy strategy

Due to its large agricultural and forestry sectors, Texas has an abundance of biomass energy resources within a wide variety of land, climate and soil conditions. Texas biomass is already producing fuel, electricity, and ethanol and biodiesel biofuels while creating jobs from clean, sustainable sources of energy.

In July 2007, Texas Governor Rick Perry announced the Texas Bioenergy Strategy, and awarded a \$5 million Texas Emerging Technology Fund grant to Texas A&M University for research and biofuel advancements. In a four-year project, Texas A&M and the Chevron Corporation are partnering on research efforts to find ways to speed up harvesting of cellulose crops and turning them into biofuels. The governor said that Texas will focus on creating biofuels through cellulosic feedstock such as switchgrass, wood chips and corn stems – rather than from corn crops, which are a staple for the Texas cattle industry

New areas of research

There are a number of traditional and non-traditional biomass sources that remain underutilized for bioenergy production. There is much potential for such traditional crops as cassava, coconut, and sugarcane to be revitalized and used as sustainable bioenergy sources. Other potential bioenergy sources are rice bran,

miscanthus, switchgrass, hemp, poplar, and willow.

It must be emphasized, though, that with limited farmland, biomass production for energy must not compete with food production. The efficacy, safety and cost-efficiency of biomass production for fuel products must be considered, keeping a balance between energy production and food production.

At the same time, the non-traditional crop, *Jatropha*, a hardy plant resistant to drought and pests that produces seeds with up to 40 percent oil content, has now gained much popularity worldwide as a bioenergy source. When the seeds are crushed, the resulting *Jatropha* oil can be used as biodiesel, while the residue can also be processed into biomass to power electricity plants.

An exciting development on the horizon is production of biodiesel from algae. Given the right conditions some species of algae grow at very high rates, up to 30 times the rate for land plants.

Of special interest is the possibility of using sea water in large shallow desert ponds. A major problem is that constant high temperatures facilitate high yields, but large-scale energy production would involve large, open ponds in deserts, where temperatures fall at night. Siting ponds close to power plants would enable use of warm cooling water.

Biomass Energy Industries

As reported by the U.S. Department of Energy and other sources

ADAGE. AREVA and Duke Energy have launched a joint venture company, ADAGE, to develop biomass-to-electricity projects. AREVA will design and build biomass power plants, while Duke Energy Generation Services (DEGS) will manage operations. AREVA has designed and built more than 100 biopower facilities in Europe, Asia and South America with capacity of more than 2,500 MW.

Austin City Council has approved a \$2.3 billion purchasing agreement for what will become the largest wood-waste-fueled biomass plant in the United States. The city will buy all power produced by the 100-MW Sacul, Texas, plant for the next 20 years. The facility will generate power from burning wood waste from logging and mill operations, urban waste from tree clearing and trimming, and from shipping pallets. Completion is planned for 2012.

Avista Corporation has a power plant at Kettle Falls, Wash., (north of Spokane) burning lumber mill wood wastes from the surrounding sites in Washington and Canada.

Boralex Inc., a Canadian firm, operates the Stratton Energy power plant in Maine. The company owns several hydroelectric plants and other biomass plants. The 45-MW facility sells power to broker Cinergy.

Burlington Vermont Electric Department operates the Joseph C. McNeil Generating Station, reported to be the largest U.S. utility-owned, wood-burning power plant.

Capco Energy has developed three biomass energy plants near Fresno in central California. They were set up to burn a number of types of agricultural and wood wastes, including almond prunings, cotton stalks, corn stalks, vineyard prunings, straw, and forest residue.

Colmac Energy operates a 49-MW wood-fired power plant in Mecca, Calif., southeast of Palm Springs. It is one of three biomass plants in Southern California handling wastes from citrus and date orchards in the Los Angeles basin. Most of the wastes would otherwise have to be land-filled.

Covanta Energy operates a waste incinerator in Alexandria, Va. Fuel includes mattresses, campaign signs, broken office furniture, yard waste and trash bags by the thousands. Some 150 trucks from Alexandria, Arlington, the District and from communities in Maryland discard up to 1,500 tons (1,361 metric tons) of garbage a day at the incinerator. All of it is municipal waste.

Grayling Generating Station in north central Michigan provides electricity to a remote region, using wood wastes such as hog fuel bark, forest residues and mill scraps.

GreenHunter Energy Inc., Grapevine, Texas, has announced plans to locate a biodiesel production refinery at Tampa, Fla. The \$70 million project would use vegetable oil as stock for biofuels during initial operations but later may switch to animal fat.

Kimberly-Clark Corporation and **Snohomish County Public Utility District** have a 43-MW facility at Kimberly-Clark's paper mill in Everett, Wash. Snohomish sells most of the electricity to the Sacramento Municipal Utility District

The **Klamath Tribes** in Oregon say a proposed biomass energy plant would cost about \$8 million to \$12 million to build. Tribal leaders are meeting with potential partners on the project planned for the former Crater Lake Mill site 25 miles (40 km) north of Chiloquin. Preliminary plans call for an 8-MW plant that would use a variety of biomass sources, such as woody material and solid waste from urban areas. At full

capacity, the plant could provide energy for about 4,000 homes. The tribes purchased the site planning for an industrial park with other forest products businesses, such as wood bundling services and small diameter pole and post manufacturing.

Northern States Power Company operates the biomass Bay Front Station near Ashland, Wis., which consumes wood wastes, old railroad ties and shredded rubber.

Oglethorpe Power Corp., the Georgia-based utility, will invest up to \$1 billion building two power plants fueled by biomass. The two 100-MW plants, powered by woody biomass from South Georgia's vast forests, are due to begin production in 2014 and 2015. The company also may decide to build a third facility, which also would go online in seven years.

Pacific Corporation. In Oregon, there is a co-generation power plant at the Camas paper mill, near Portland. The plant burns wood wastes and spent liquors from the mill. Excess power is sold to the Pacific Corporation.

Ridge Generating Station Limited Partnership owns an independent power-producing unit between Auburndale and Lakeland, Fla., that burns waste wood, waste tires, and landfill gas. Power is sold to Florida Power Corporation.

Southeast Renewable Fuels: Aaron Pepper, CEO of Southeast Renewable Fuels, plans to produce ethanol from South Florida sorghum. If he has his way, ethanol will soon come from the shores of Lake Okeechobee. His Fort Lauderdale company seeks to build three factories by the lake to produce the biofuel from sweet sorghum.

Tacoma Public Utilities operates Steam Plant No. 2, a multi-fueled generating facility located in an industrial area near Puget Sound (Washington).

Tracy Biomass, east of Oakland, handles wood wastes from central California sites, serving a million acres (404,686 hectares) of orchard land and the major landfills for the San Francisco Bay area.

U.S. Generating Co. and Flo-Energy Corp. operate the Okeelanta Cogeneration Plant next to the Flo-Sun Inc. Okeelanta Sugar Mill, near South Bay in Palm Beach County, Fla. It is the largest bagasse/biomass cogeneration plant in the United States. Excess electricity is sold to FPL.

Vermonters are going to be getting more electricity from garbage. The Moretown Landfill is launching a program to make electricity from methane gas produced by the rotting trash. Officials say that once the project is online, it will be capable of producing enough electricity to power about 2,600 homes and keep about 21,600 tons (19,595 metric tons) of carbon dioxide from being released into the environment.

Virginia Power: What is said to be the world's largest stand-alone wood-fired power plant is located at Hurt, Va. It consumes sawmill chips, sawdust, tree chips, and shavings.

Wheelabrator Shasta Energy Company runs a wood-fired power plant at Anderson, between Sacramento and Redding in Northern California. The plant processes some 750,000 tons (680,396 metric tons) per year of mill wastes and forest debris from Shasta County and other areas.

8. Electricity Storage Industries

Ever since the discovery of the light bulb, those seeking the full benefits of electricity have been frustrated by the lack of storage capability. For decades, mankind has extended wires from distant generators or used batteries of very limited capacity. The pressure has built and the prize has gotten larger for those who can develop systems that store electricity for long times in large amounts.

Jobs! Energy!

The impressive growth of solar power to date has been achieved despite what many have thought would be a permanent handicap – lack of storage capability. Critics have long said solar can't compete with coal or nuclear systems because it is limited on cloudy days and shuts down completely at night.

Now, that assumption is becoming invalid. It has been demonstrated that solar energy can be stored at high temperatures using molten salts. Salts are a preferred storage medium because they are non-flammable, nontoxic, low cost, have a high specific heat capacity, and can deliver heat at temperatures compatible with conventional power systems.

The Solar Two project in California used molten salt storage to help adjust for cloudy days. The salt storage was 60 percent sodium nitrate and 40 percent potassium nitrate. The molten salt also allowed the energy to be stored in large tanks for future use such as night time. Molten salt storage is now being used in Nevada's Solar One power plants.

Using such a system, start-up Ausra says its plants will be able to store heat for up to 20 hours, allowing it to sell electricity to the grid whenever demand is greatest. Hamilton Sundstrand, a division of United Technologies, has announced the creation of a new company named Solar Reserve that will produce heat-resistant pumps and other equipment for handling and storing salt at temperatures over 1,000F (538C).

Another approach to energy storage that is getting much attention is fuel cells. Jadoo Power, a Mohr Davidow-funded company based in Folsom, Calif., is producing small hydrogen fuel cells for the military and private users. It plans to sell a rechargeable hydrogen fuel cell that can power homes.

Silicon Valley venture heavyweights Kleiner Perkins Caufield & Byers and New Enterprise Associates are backing Bloom Energy, a solid-oxide fuel cell company that has raised \$102 million. Superprotonic, backed by San Francisco-based Nth Power, is commercializing solid-acid fuel cells for cars. Depending on what power source it's replacing, storage is pre-

dicted to be at least a \$12 billion market by the end of the decade.

Rural areas in developing countries stand to benefit the most from new developments in the storage of solar energy. There are about two billion people whose homes are not connected to an electrical grid. Today rechargeable batteries are widely used to store electricity from small photovoltaic systems.

Today, there are fabulous opportunities just ahead. These tantalizing incentives are producing a boom in launching new ventures and expanding existing industries related to electricity storage. Established firms, such as battery manufacturers, are investing heavily in research. Scores of start-ups are attracting millions of dollars in venture capital in order to pursue new types of fuel cells and other ideas flowing from research labs. Here's a quick look at the state of the art:

Large systems

The leading form of grid energy storage today is *pumped water storage*. At many locations around the world a substantial part of the energy that drives hydroelectric power plants is water pumped from a low level up to a high reservoir during the time when most customers are sleeping. The system uses cheap, off-peak electric power to run the pumps. Then, during periods of peak power demand, the water is released to flow through generator turbines, enabling the utility to maximize power at times that it charges higher rates.

More recently, *compressed air energy storage (CAES) systems* are being developed for wind farms and other intermittent sources. Power produced during periods of strong winds is used to compress air and store it in underground geologic structures. During peak power demands the air is released, mixed with a fuel and used to power combustion turbines. A 300-MW system is being planned for the Iowa Stored Energy Park (ISEP) near McIntosh.

Another approach is via what are termed "*flow batteries*," in which an electrolyte flows through a power cell that converts chemical energy to electricity. These systems involve combinations of sodium sulfide/bromide, vanadium, zinc-bromide and other dissolved electroactive materials. There is also much research on "*NAS Batteries*" based on sodium (Na) and sulfur (S) for high temperature applications.

Experts argue that *metal-air batteries* are the most compact and, potentially, the least expensive batteries available. They are limited at present because of problems with recharging. When this handicap is overcome, they will become attractive. The fact that they are environmentally benign will help.

Intermediate and smaller systems

Lithium-ion batteries are widely used in portable consumer electronic products. Also in general use are *Ni-Cad batteries* using nickel oxide hydroxide and metallic cadmium as electrodes. Most common are *lead-acid batteries*, the oldest type of re-

chargeable battery. Such types are used in automobiles and many other applications.

On the horizon are new designs that promise to extend performance parameters greatly. For example, “*super capacitors*” now being developed have a storage capacity thousands of times greater than a typical D-cell electrolytic unit. Also attracting attention are high-energy fly wheels that spin more than 20,000 rpm in a vacuum case. Their main problem seems to be the risk of an exploding flywheel – necessitating enclosing them in a heavy metal vault or locating them underground.

Perhaps the most speculative new development is the *Superconducting Magnetic Energy Storage (SMES)*. Such systems store energy in the magnetic field created by the flow of direct current in a superconducting coil in a cryogenic environment. Another very promising approach is development of *vanadium batteries*.

To date, none of these systems fills the national need for a system for storing electricity from solar, wind, and other renewable sources for months – making it possible to feed it to our grid as needed and reduce our dependence on imported fossil fuels. For the average citizen, the pot of gold at the end of the rainbow would be a small electricity storage

system for serving any single off-grid home with dependable power – making the home electrically independent.

What do leading scientists think are the most likely solutions to the storage challenge? Here’s what Dr. Gene Berry of the Lawrence Livermore National Laboratory told a conference recently:

“The storage needs of a predominantly (intermittent) renewable electricity supply may ultimately be best met in the future by increasing levels of integration with a hydrogen (H₂) fueled transportation sector. In addition to reducing greenhouse gases from transportation, this long-term option could have unique energy security, electricity reliability, and market-efficiency benefits which may be foregone if H₂ production, storage, and vehicle technologies are not developed and deployed in coordination with intermittent renewables.

“It is therefore important that hydrogen research and development efforts focus on technologies enabling efficient integration of future carbon-free transportation and electricity generation. Examples would include much higher-efficiency electrolysis and fuel cells, and reversible systems that can produce H₂ from electricity as well as electricity using H₂, potentially in homes or on vehicles.”

Companies in Electricity Storage Industries

What firms will explode into prominence tomorrow? A cursory scan reveals a fascinating mix. There are long-established global giants, middle-sized enterprises filling niches, and a host of start-ups armed with multi-million dollar venture capital funding. They are found around the world.

ABB Switzerland Ltd. Brown Boveri Strasse 5, CH-8050 Zurich, Switzerland. Tel: +41 58 5881647. www.abb.com. Long-established global supplier of diverse energy systems

Active Power Inc. 2128 W. Braker Lane, BK12, Austin, TX 78758. Tel: 512.836.6464. UPS systems

Advanced Measurements Inc. 6205-10th Street SE, Calgary, AB Canada T2H 2Z9. Tel: 877-571-7273. Fuel cell systems

Adventis Technologies. 77 King Street West, TDC 1015, Toronto, Ontario Canada M5K 1P2. Tel: 905-901-4791. Hydrogen fuel generators

AIC Labs. 5705 Hollis St., Emeryville, CA 94608-2513. Tel: 510-956-1467. Fuel cell electrochemical generators

Alternative Fuel Systems Ltd. Spring Copse Business Park, Slinfold, West Sussex, United Kingdom RH13 7SZ. Tel: +44 (0) 1403 791116. Hydrogen fuel cell generators

Aluminum Power Inc. 907 Alness St., Toronto, Ontario, Canada M3G2N. 2416-661-6614. Aluminum air fuel cells

Analog Devices. Norwood, MA. www.analog.com. A global firm with some 10,000 employees in semi-conductor business. Has recently opened power management research center in Richardson, TX.

Analytic Power Corporation. 100 Cummings Park, Woburn, MA 01801. Tel: 781-932-8080. Fuel cell batteries, residential PEM fuel cell power generators

A123Systems. 321 Arsenal Street, Watertown, MA 02472. One of the world's leading suppliers of high-power Lithium-Ion batter-

ies, using proprietary nanoscale electrode technology from MIT. More than 1,000 employees. Major investors include General Electric, MIT, Motorola, and others. A123 has a contract manufacturing agreement with China BAK Battery, a firm with a new facility making LiFePO₄ battery cells in the Tianjin Beichen Hi-Tech Industrial Park in northeast China.

Amara Raja Batteries Ltd. Tirupati, India. A large manufacturer of Standby Valve Regulated Lead Acid (VRLA) batteries.

Applied Materials. 3050 Bowers Avenue, P.O. Box 58039, Santa Clara, CA 95054-3299. Tel: 408-727-5555. Long-established firm. Semiconductor Nanomanufacturing Photovoltaic FPD Thin Films.

Axion Power International Inc. 100 Caster Avenue, Woodbridge, ON L4L 5Y9 Canada. Tel: (905) 264 1991. E-mail: info@axionpower.com. Developing what it calls a "hybrid energy storage device" with the characteristics of both batteries and supercapacitors.

Ball Aerospace & Technologies. 1600 Commerce St., Boulder, CO 80301. Tel: (303) 939-4000. Fuel cell systems

Ballard Power Systems. 9000 Glenlyon Parkway, Burnaby, BC, Canada V5J 5J9. Tel: 604-454-0900. Proton exchange membrane (PEM) fuel cells

Beacon Power Corporation. 65 Middlesex Road, Tyngsboro, MA 01879. Tel: (978) 694-9121. Energy storage flywheel systems

Bloom Energy. Silicon Valley venture heavyweights Kleiner Perkins Caufield & Byers and New Enterprise Associates are backing Bloom Energy, a solid-oxide fuel cell company that has raised \$102 million.

Cetech America Inc. P.O. Box 522050, Longwood, FL 32752. Tel: 407.322.5199. Fuel cell systems, hydro energy systems

Cipher Technology. 2016 Trinity Lane, McKinney, TX 75070. Tel: (214) 592-9652. Solar Panels, DC to AC power inverters, fuel cell systems

Citation Corporation. 27275 Haggerty Road, Suite 420, Novi, MI 48822. Tel: (248) 761-1805. Water pumps, fuel cell systems, steam turbine electric generators, wind energy system components

Clear Energy Inc. 1100 Wilson Dr., Baltimore, MD 21223. Tel: 410 646-1536. Hydrogen gas generators, thermal electric hydrogen generators, SDC hydrogen generators, on-board hydrogen generators

Cobasys. HQ, 3740 Lapeer Road South, Orion, MI 48359. Tel: 248-620-5700. E-mail: info@cobasys.com. A joint venture between Chevron subsidiary Chevron Technology Ventures and Energy Conversion Devices. Operates \$137 million manufacturing plant 50 Ovonic Way, Springboro, OH 45066. Tel: 937-743-1001. E-mail: info@cobasys.com. Produces battery systems for hybrid electric vehicles (HEVs) and systems that supply stationary back-up power.

Comco. Anurag, Shivram Soc. Devidayal Rd., Mulund-W., Mumbai, Maharashtra, India 400080. Tel: 91-982-184-6299. Battery chargers, DC to DC power converters, fuel cell systems

Crown Battery Mfg. Co. 1445 Majestic Drive, P.O. Box 990, Fremont, OH 43420. Tel: (419) 334-7181

Cummins Inc. Box 3005, Columbus, IN 47202-3005. Manufacturer and worldwide distributor of engines and related technologies, including fuel systems, controls, air handling, filtration, emission solutions and electrical power generation systems.

Dais-Analytic Corporation. 11552 Prosperous Dr., Odessa, FL 33556. Tel: 727-375-8484. Polymer membrane-based, fixed-plate enthalpy exchangers; membrane energy recovery ventilators; proton exchange membranes; ionomer membranes

EaglePicher Inc. HQ, 2424 John Daly Rd., Inkster, MI 48141. Tel: 313.278.5956. Plants at Pittsburg, KS; Joplin, MO; and elsewhere. Owns controlling interest in Korea-based Kokam Engineering Co. Ltd., a maker of rechargeable lithium-ion batteries. Kokam located new HQ in the Kansas City-area community of Lee's Summit, MO.

ElectroChem Inc. 400 W. Cummings Park, Woburn, MA 01801. Tel: 781-938-5300. Fuel cells and fuel cell testing equipment

Electro Energy Inc. 30 Shelter Rock Road, Danbury, CT 06810. Tel: 203-797-2699. www.electroenergyinc.com. Bipolar cell and battery designs utilizing NiMH chemistry, as well as expanding development to include Li-ion chemistries. New plant, Alachua, FL

Eneco Ltd. Unit 6, Spring Copse Business Park, Slinfold, Nr. Horsham, West Sussex, United Kingdom RH13 0SZ. Tel: +44 (0)1403 790114. Hybrid power systems, fuel cell systems

Energy Partners. 1501 Northpoint Parkway, Suite 102, West Palm Beach, FL 33407. Tel: (407) 688-0500. Hydrogen fuel cell systems

Energy Storage and Power Corp. 40 Woodman Lane, Basking Ridge, NJ 07920. Tel: 908-658-4484. A leader in technology for the conversion of compressed air energy into electric power

Energys Inc. 2366 Bernville Road, Reading, PA 19605. Tel: 800-538-3627. 610-208-1991. One of the world's largest industrial battery companies. New plant, Warrensburg, MO.

eVionyx Inc. 6 Skyline Dr., Hawthorne, NY 10532. Tel. 914-345-0321. Investors include Niagara Mohawk and Cheng Xin Technology Development Corp.; it has raised \$80 million in funding. Fuel cells

Exide Technologies Inc. 13000 Deerfield Pkwy., Bldg. 200, Alpharetta, GA 30004. Part of Exide battery corp. New plants – Bristol, TN, and Haldia, India.

FuelCell Energy Inc. 3 Great Pasture Road, Danbury, CT 06813. Tel: 203-825-6000. Fuel cells, fuel cell power plants. Recently announced a \$10-million expansion of its Torrington plant

Fuel Cell Technologies. 20 Binnington Court, Kingston, ON Canada K7M 8S3. Tel: 613-544-8222. Fuel cell systems, fuel cell system components, solid oxide fuel cell power systems (SOFC)

Gaia Power Technologies Inc. 116 John Street – Suite 820, New York, New York 10038. Tel: 212.732.5507. Gaia's standard unit can power a 2,000 sq. ft. home through 95 percent of all power outages. www.gaiapowertech.com.

GridPoint Inc. 2801 Clarendon Blvd. Suite 100, Arlington, VA 22201. Tel: 703-667-7000. GridPoint Protect is a power backup that uses gel-style batteries. Founded in 2003, GridPoint has raised \$18 million from venture capital firms and private investors and now employs a staff of 50.

Heliocentris Fuel Cells AG. Rudower Chaussee 29, Berlin, 12489, Germany. Tel: +49-306-392-6325. A leading system integrator for fuel cells and Ovonic Hydrogen Systems, a subsidiary of Energy Conversion Devices Inc., has signed a sales agreement for hydrogen storage systems.

Horizon Fuel Cell Technologies. 5 Shenton Way, #23-03 UIC Building, Singapore 068808. Tel: (+65) 64089785. Claims to be the first company to commercialize consumer fuel cell products, with customers in 35 countries around the world. www.horizonfuelcell.com

H Power. 60 Montgomery Street, Belleville, NJ 07109. Tel: 973-450-4400. Fuel cell systems

Hydrogenics Corporation. 5985 McLaughlin Rd., Mississauga, ON Canada L5R 1B8. Tel: (905) 361-3639. PEM fuel cell power products, 4-16 kW electrolyzer-based hydrogen station products

Hydrogen Fuel Cell Motorsport. Woodham Court, Woking, United Kingdom GU215NJ. Tel: 0044 7771 895 429. Fuel cell systems

IdaTech. 63065 NE 18th Street, Bend, OR 97701. Tel: 541-383-3390. Remote power, portable power

IE Power Inc. 4170 Sladeview Crescent, Unit 1, Mississauga, ON L5L 0A1, Canada. Tel: (905) 813-8900. Designs and manufactures DC and AC power converters in power ranges up to tens of megawatts E-mail: iepower@iepower.com.

International Components Corporation. 420 N. May Street, Chicago, IL 60622. Tel: (312) 829-2525. Consumer electronics batteries, battery chargers, battery connectors, portable power systems

International Fuel Cells. 195 Governors Highway, P.O. Box 739, South Windsor, CT 06074. Tel: 860-727-2200. Fuel cell batteries, fuel cell power plants

Ion Power Inc. 720 Governor Lea Road, New Castle, DE 19720. Tel: (302) 832 9550. Membrane Electrode Assemblies (MEAs) for hydrogen fuel cells and electrolyzers

ITI Energy. 6th Floor, The Exchange No 1, 62 Market Street, Aberdeen, AB11 5PJ, Scotland. Tel: +44 1224 282630. Developed over 10 years at Newcastle University, the ITI Energy Gasifier was specifically designed to handle a wide range of "difficult" or negative-value feedstocks and is particularly suited to the conversion of Refuse Derived Fuel (RDF) into energy. www.itienenergy.com.

Johnson Controls Inc. Milwaukee, WI. www.jci.com. Climate control systems. A global firm with 140,000 employees. Recent new plant at Nersac, France

Lacey Manufacturing Inc. PO Box 2024, Albany, NY 12220. Tel: 877-276-0640. Fuel cell systems, gas turbine electric generators, fuel-powered electric generators, hybrid electric vehicles

Lynntech Inc. 7610 Eastmark Dr., College Station, TX 77840. Tel: 979-693-0017. Fuel cells, air filtering and purification systems, water filtering and purification system components

Lynntech Industries Ltd. 3900 State Hwy 6 South, Ste 104, College Station, TX

77845. Tel: 979-693-0017. Fuel cell test systems, direct methanol test kits

Manu Energy Systems Pvt. Ltd. 49-53-7/13, Sampada Galaxy, B.S. Layout, Visakhapatnam, Andhra Pradesh, India 530013. Tel: +91 891 2503895; +98480 29091. Fuel cell systems

Panasonic (formerly Matsushita Electric Industrial Co. Ltd). A large electronics manufacturer based in Kadoma, Osaka Prefecture, Japan

Maxwell Technologies Inc., 9244 Balboa Avenue, San Diego CA 92123. Tel: +1 858 503 3300. PowerCache ultracapacitors claim up to 100 times the energy of conventional capacitors and ten times the power of ordinary batteries.

Monbat Industries, 102 Bulgaria Blvd., BC Belisimo, Floor 7, 1680 Sofia, Bulgaria. Tel: (+359 2) 962 11 50. E-mail: monbat.trading@monbat.com

Monbat PLC. PO Box 149, ul Industrialna 76, Montana, Bulgaria. Tel: 359 096 393 101, www.monbat.com. Subsidiary of Texaco Chevron. Storage battery mfg.

MTI MicroFuel Cells, 431 New Karner Road, Albany, NY 12205. Tel: 518.533.2222. Has developed a miniaturized direct methanol fuel cell (DMFC) technology called Mobion

NeuroFlash Pte Ltd. #04-55, Block 203, Hougang Street 21, Kovan, Singapore 530 203. Tel: +65 6282 1992. Fuel cell system components

NGK-Locke Inc. 2525 Insulator Drive, Baltimore, MD 21230. Tel: (410) 347-1700. Began operation in the U.S. as NGK Insulators of America Inc. as an exclusive sales division of NGK Insulators Ltd., Japan. The name became NGK-Locke Inc. when a joint venture between General Electric and NGK was formed.

NorthStar Battery Co. 4000 E. Continental Way, Springfield, MO 65803. Tel: (417) 865-5998. Has announced a \$73-million project that will add 400 new employees

Nu-Devices Inc. 6200 Commerce Loop, Post Falls, Idaho 83854. Tel: 208-676-0553. Custom power supplies

NuVant Systems Inc. 10 West 33rd Street, Perlstein Hall 127, Chicago, IL 60616. Tel: (888) 373-0303. Fuel cell systems and components

Palcan Fuel Cell Co. Ltd. 1152-4250 Westbrook Mall, Vancouver, BC Canada V6T1W5. Tel: 604 288-7822. Power generators and metal hydride storage systems.

Pentadyne Power Corp. 20750 Lassen St., Chatsworth, CA 91311. Tel: 818-350-0370. Flywheel energy storage systems E-mail: davidtownley@pentadyne.com.

Phocos AG. Eberhard-Finckh-Strasse 10, Ulm, Germany D-89075. Tel: +49 (731) 940 20 88-0. Solar battery charge controllers, fuel cell systems

Phoebus Tech. Engineering Inc. SA de Cv. J.J. Eguiara y Eguren 117, Mexico D.F., Mexico 08200. Tel: 52 55 55199460. Fuel cell systems, small water turbine electric generators from 1W up to 400W

Phostech Lithium Inc. 6721, rue Beau-bien Est, Montreal, QE H1M 3B2 Canada. Is devising a new form of lithium-iron phosphate (LiFePO₄) for use in the manufacture of cathodes. An affiliate of German firm Süd-Chemie AG. Recent \$35 million expansion

Pivotal Power. 150 Bluewater Road, Bedford, NS Canada B4B 1G9. Tel: (902) 835-7268. Backup power systems, DC-to-DC power converters, DC-to-AC power inverters, fuel cell systems.

Plug Power. 968 Albany-Shaker Road, Latham, NY 12110. Tel: 518-782-7700. Fuel cell systems

PolyFuel. 1245 Terra Bella Avenue, Mountain View, CA 94043. Tel: 650.429.4700. E-mail: info@polyfuel.com. Fuel cells

Powerzinc Electric Inc. 17800 E. Castleton St., Suite 435, City of Industry, CA 91748. Tel: (626) 810-3068. Zinc-air fuel cell and zinc-air battery

Proton Energy Systems Inc. 10 Technology Drive, Wallingford, CT 06492. Tel: 203.678.2000. Fuel cell systems, hydrogen generators

ReliOn. 15913 E. Euclid Ave., Spokane, WA 99216. Tel: 509-228-6500, 1-877-474-1993. fuel.cells@reliion-inc.com. \$60 million venture capital funding. Hydrogen fuel cells.

ReneSola Ltd. A leading manufacturer of silicon wafers for the photovoltaic industry.

S&C Electric Company. 6601 North Ridge Boulevard, Chicago, IL 60626-3997. Main Offices: Tel: (773) 338-1000. Power quality systems

Saft (Safety Insurance Group, Inc). 12, rue Sadi Carnot, 93170 Bagnolet, France. Tel.: +33 (0)1 49 93 19 18. Li-ion batteries for Galileo mission with the launch of the GIOVE-B experimental satellite

SANYO Electric Co. Ltd. 2-5-15 Hiyoshi-cho, Moriguchi-shi, Osaka 570-8634, Japan. Tel: +81-6-6992-1521. www.sanyo.com.jp A huge global firm. Solar panels and cells

SatCon Technology. 27 Drydock Avenue Boston, MA 02210. Tel: (617) 897-2400. SatCon Power Systems manufactures and sells static power conversion and energy management systems utilizing power electronics and advanced controls.

Siemens AG, Munich, Germany, is Europe's largest engineering conglomerate with 6 major divisions. Siemens Energy & Automation Inc. is headquartered in the Atlanta suburb of Alpharetta, GA.

Solicore Inc. 2700 Interstate Dr., Lakeland, FL 33805. Tel: (863) 904-1482. High-energy lithium polymer batteries, known as Flexion, that incorporate the company's patented non-combustible, non-toxic, solid-state electrolyte (SSE) technology.

Sony Corp. Minato-ku, Tokyo, Japan. One of the world's largest media conglomerates with annual revenue more than \$70 billion. In 2008 announced a fuel-cell system small enough to fit in one hand. The device combines a fuel cell, Li-polymer secondary battery, and control circuit. Sony had previously announced a fullerene-type solid polymer

electrolyte membrane and MEA (membrane-electrode assembly).

Sukan Engineering Pvt Ltd. 302, Acme Plaza, Opp Sangam Cinema, Andheri Kurla Rd., Andheri East, Mumbai, Maharashtra, India 400059. Tel: +91 22 8235707. Fuel cell systems, hydrogen gas generating plant.

Superprotonic. 530 S. Lake Ave. #312, Pasadena, CA 91101. Backed by San Francisco-based Nth Power, is commercializing solid-acid fuel cells.

Tianjin Highland Energy Technology Development Co. Ltd. 3rd Floor, No. 80, 4th Street, TEDA, Tianjin, China 300457. Tel: ++86-22-66211073. Metal hydride hydrogen storage tanks and gauges.

Toshiba America Electronics Components Inc. 19900 McArthur Blvd., Suite 400, Irvine, CA. Tel 949-620-2900. Direct methanol fuel cells.

Trojan Battery Company, 12380 Clark Street, Santa Fe Springs, CA 90670. Tel: 800-423-6569. New plant at Sandersville, GA.

Tropical S.A. 98 Kifisou Avenue, Peristeri, Athens, Greece 121 32. Tel: +30 210 578-5455. Hydrogen fuel cell systems (100 W to 20 kW)

United Solar Ovonic LLC. 3800 Lapeer Road, Auburn Hills, MI 48326. Tel: 248-475-0100. www.uni-solar.com. The world's largest manufacturer of triple junction amorphous silicon photovoltaic (PV) solar panels for converting sunlight into electricity. A wholly owned subsidiary of energy conversion devices.

VRB Power Systems Inc. Suite 200, 13955 Bridgeport Road, Richmond, BC V6V 1J6 Canada. Tel: (604) 247-3300. Producer of Vanadium Redox Battery Energy Storage System.

Vycon. 23695 Via Del Rio, Yorba Linda, CA 92887. Tel:1-714-386-3800. E-mail: sales@vyconenergy.com. Flywheel energy storage systems

Yuasa Battery Inc. Laureldale, PA.

Project New America

ZBB Energy. N93 W14475 Whittaker Way, Menomonee Falls, WI 53051. Tel: 1 (262) 253-9800. Produces a 540-volt, 500-kWh-hour, thermal-controlled battery energy storage system that's easily transported.

Zoxy Energy Systems AG. Carl-Benz-Str. 2, Bretten, Germany 75015. Tel: +49 7252 9631-0. Zinc-air energy cells

Ztek Corporation. 300 W. Cummings Park, Woburn, MA 01801. Tel: (781) 890-5665. Fuel cell systems, cogeneration systems

9. Power Transmission Industries

This category includes firms that carry electricity from generating plants to residential and commercial customers. They maintain a power grid on which they regulate the voltage and control the flow. The complex system extends from huge nuclear power plants via high-tension lines to regional and local arteries down through transformers to individual lines and, eventually, to meters at homes and offices.

Jobs! Energy!

It is fair to say that the present U.S. electric power grid is a patchwork of confused jurisdictions and facilities. It has been pieced together as the nation has grown and, most of the time, it has served adequately. However, the urgent need for modernization has been demonstrated by catastrophic brownouts and blackouts. As large new energy sources such as wind and solar have emerged, they have encountered problems getting their output to customers. For example, the new Maple Ridge Wind Farm near Lowville, NY – one of the largest in the country – has had to shut down at times when the grid serving its area was overloaded and could not deliver its output.

Unlike other energy categories, the U.S. electric power industry has been intensely regulated. In recent years there have been numerous changes in regulation and deregulation aimed at making the industry more competitive. In some areas, customers can now choose the company from whom they wish to buy electricity. Also, barriers have been taken down to allow power firms to expand wherever

they see markets. This has provided an exciting opportunity for aggressive utilities to play a new role in the nation's economic development.

Until recently the business of traditional electric utility firms has been limited to the generation and distribution of electric power. Like a lot of other companies, they manufacture a product and sell it. However, theirs is a different kind of manufacturing business: First, the product of the electric utilities can't be stored. Second, their product can be delivered only to customers connected to a power grid.

Thus, for many years electric utilities have sought to gain new business by luring customers to come to them. They are major players in the field of area economic development. When they attract a new industrial plant to their geographic territory, they have landed an important new customer and created new jobs.

A few utility firms have expanded by setting up operations outside the United States. As far back as the

1960s I recall visiting American and electric power affiliates in Colombia and Panama. Unlike other manufacturers, however, few have built plants in new U.S. locations outside of their present territory in order to find new customers.

Why not? For one thing, in many areas, bureaucratic regulations have limited electric utility firms to specified franchise territories. Healthy competition has been stifled. Creative managers have been frustrated. For decades this situation has been the accepted norm.

Within the past few years there has been a dramatic change in thinking. The need to reduce emissions and limit the import of expensive fossil fuels has led to exploration of alternative energy sources and the need for new strategies.

This change is strikingly illustrated by Florida Power and Light. An allied firm, FPL Energy LLC, a subsidiary of FPL Group (NYSE: FPL) has developed Horse Hollow Wind Energy Center in Texas – one of the largest wind farms in the world. It has a total capacity of 735 MW. The center is comprised of 291 GE 1.5-MW wind turbines and 130 Siemens 2.3-MW wind turbines.

The site is spread over nearly 47,000 acres (19,020 hectares) in Taylor and Nolan County, Texas, near Abilene and Sweetwater in the I-20 corridor. The big project gives FPL Energy more than 1,600 MW of wind power in Texas alone.

According to Jim Robo, president of FPL Energy, “The Horse Hollow

Wind Energy Center is an important new source of clean, renewable power for the region that also provides significant economic benefits to the area in the form of taxes, new jobs, lease payments to landowners and the purchase of local goods and services. ... Projects like Horse Hollow are possible because of the pro-business environment that exists in Texas today as well as tremendous support from the local community. Because of the strong support we have received in Texas, this year alone we have invested more than \$1 billion to expand our wind business in the state and bring the benefits of this clean, renewable energy source to tens of thousands of Texans.”

FPL Energy, through its subsidiaries, currently operates 47 wind farms throughout the United States, with a gross capacity of 4,002 MW – enough capacity to provide electricity for nearly one million average U.S. homes. FPL Energy is said to be the largest owner and operator of wind turbines in the world.

FPL Energy subsidiaries own 3,793 of the 4,002 MW they currently operate. Since July 2005, FPL Energy has added approximately 880 MW of new wind power. With a backlog of wind project contracts in place, FPL Energy expects to add at least 1,500 MW to its portfolio, excluding acquisitions, during 2006/2007. In the first half of 2006, FPL Energy’s development activities helped Texas overtake historic leader California as the top state in cumulative wind power capacity, according to the American Wind Energy Association (AWEA).

Today FPL Energy is a leading wholesale generator utilizing clean fuels such as natural gas, wind, solar, hydroelectric and nuclear to generate electricity. It is a subsidiary of FPL Group, one of the nation's largest providers of electricity-related services with annual revenues of more than \$10 billion. FPL Group's principal subsidiary is Florida Power & Light Company, one of the nation's largest electric utilities, which serves more than 4.3 million customer accounts in Florida.

Obviously the creative thinkers at FPL have found an important new way to reach new customers for their product. They have opened the door to a new era of exciting developments in the energy field. Significantly, FPL has become a seeker of new sites – an investor now sought after by area development agencies.

In a rapidly changing business world, how many other utilities will expand their options by seeking new sites as well as selling and promoting sites they currently serve? We think a lot of utility executives will discover what it's like to be on both sides of the site promotion profession – acting as both hunter and prey.

Top priority!

All of these new developments have underscored the need for a thorough analysis of our national grid and prompt action to strengthen and modernize it. Experts propose the construction of an interstate electric grid analogous to our interstate highway system. I believe such a federal program is essential to the success of **Project New America**.

First, we need a new high-voltage North/South line extending from Texas across the Great Plains to Montana. It would collect wind energy from the many new wind farms being built in the region.

Next we need an East/West line running from Southern California across Arizona and New Mexico to a point in the Midwest. This line would collect energy from solar plants in the desert and take it, along with wind energy, to a connection with the grid serving eastern population centers.

This project should be authorized in 2009 and the transmission lines should be operative within two years. This is imperative!

Electric Service Providers in the United States

- ABB Inc.: Norwalk, CT
- ACN Energy Inc.: Houston, TX
- AEP (American Electric Power Company): Charleston, WV
- AEP (American Electric Power): Columbus, OH
- AEP (American Electric Power): Roanoke, VA
- AEP (American Electric Power): Fort Wayne, IN
- AEP (American Electric Power): Gahanna, OH
- AEP (American Electric Power): Ashland, KY
- AEP (American Electric Power): Hazard, KY
- AEP (American Electric Power): Columbus, OH
- AEP Indiana Michigan Power Co: Fort Wayne, IN
- AEP Public Service of OK: Tulsa, OK
- AEP Southwestern Elec Power: Shreveport, LA
- AGL Resources Inc.: Atlanta, GA
- Adams Rural Electric: West Union, OH
- Aiken Electric Cooperative Inc.: Aiken, SC
- Alabama Electric Cooperative: Andalusia, AL
- Alabama Gas Corp. (Alagasco): North Birmingham, AL
- Alabama Municipal Electric Authority: Montgomery, AL
- Alabama Power Co. Southern Div.: Montgomery, AL
- Alabama Power Company: Birmingham, AL
- Alameda Power & Telecom: Alameda, CA
- Alaska Electric Light & Power Co.: Juneau, AK
- Alaska Oil & Gas Assn.: Anchorage, AK
- Alaska Public Utilities Commission: Anchorage, AK
- Allegheny Power: Greensburg, PA
- Allegheny Power: Williamsport, MD
- Alliant Energy: Albert Lea, MN
- Alliant Energy: Des Moines, IA
- Alliant Energy - Headquarters: Madison, WI
- Alliant Energy - Midwest Sites: Cedar Rapids, IA
- Altamaha EMC: Swainsboro, GA
- AmPro Energy Inc.: Sugar Land, TX
- Ameren Services: Saint Louis, MO
- Ameren Services: Decatur, IL
- AmerenIP, Ameren CILCO, Ameren CIPS: Hillsboro, IL
- American Electric Power: Corpus Christi, TX

Project New America

- American Electric Power-Michigan: Three Rivers, MI
- American Municipal Power - Ohio: Columbus, OH
- American Water Works Company Inc.: Voorhees, NJ
- Anadarko Petroleum Corp: Houston, TX
- Anadarko Petroleum Corp Oklahoma City Div: Oklahoma City, OK
- Anaheim Public Utilities: Anaheim, CA
- Anchorage Alaska Waste: Anchorage, AK
- Anchorage Water & Wastewater Utility: Anchorage, AK
- Aqua America Inc.: Bryn Mawr, PA
- Aquila: Saint Joseph, MO
- Aquila Inc: Cedar Rapids, IA
- Aquila Inc.: Kansas City, MO
- Aquila Inc.: Wichita, KS
- Aquila Inc.: Kansas City, MO
- Aquilla Energy: Pueblo, CO
- Arizona Elec Power Co-op: Benson, AZ
- Arizona Power Service (APS) (Pinnacle West): Phoenix, AZ
- Arizona Public Service: Phoenix, AZ
- Arkansas Electric Cooperative: Little Rock, AR
- Arkansas Oklahoma Gas Co.: Fort Smith, AR
- Arkansas Valley Elec Coop: Ozark, AR
- Arnold Light & Water Municipality: Arnold, MT
- Associated Electric: Springfield, MO
- Association of Missouri Electric Co-ops: Jefferson City, MO
- Atlanta Gas Light: Atlanta, GA
- Atlantic City Electric: Mays Landing, NY
- Atmos: Jackson, MS
- Atmos Energy: Owensboro, KY
- Atmos Energy Corp: Dallas, TX
- Avista Corporation: Spokane, WA
- Bailey County Electric Coop Assn: Muleshoe, TX
- Baldwin County Electric Member Corporation: Summerdale, AL
- Baltimore Gas & Electric: Baltimore, MD
- Bangor Hydro: Bangor, ME
- Basin Elec Power Coop: Bismarck, ND
- Bay State Gas: Westborough, MA
- Bay State Gas Company: Lawrence, MA
- Beauregard Electric Coop: Deridder, LA
- Benton Rural Electric: Prosser, WA
- Berkeley Electric Cooperative: Moncks Corner, SC
- Berkshire Gas Company: Pittsfield, MA
- Big Rivers Electric Corp.: Henderson, KY
- Black Hills Energy: Lincoln, NE
- Black Hills Power: Gillette, WY
- Black Hills Power & Light Co.: Newcastle, WY

Project New America

- Black Hills Power & Light Company: Rapid City, SD
- Black River Electric Cooperative: Sumter, SC
- Blue Grass Energy: Nicholasville, KY
- Blue Ridge Electric Cooperative Inc.: Pickens, SC
- Blue Ridge Electric Member Corporation: Lenoir, NC
- Blue Ridge Power Agency: Danville, VA
- Bluefield Gas Company: Bluefield, WV
- Bluepoint Gas Services Inc.: Dallas, TX
- Bowling Green Municipal Utilities: Bowling Green, KY
- Braintree Electric Light Dept.: Braintree, MA
- Bridgeport Utilities: Bridgeport, AL
- Bristol Tennessee Elec System: Bristol, TN
- Broad River Electric Cooperative Inc.: Gaffney, SC
- Brooklyn Union Gas (Keyspan Energy Corp): Brooklyn, NY
- Brownsville Public Util Board: Brownsville, TX
- Brownsville Utilities: Brownsville, TN
- Brunswick Electric Member Corporation: Shallotte, NC
- Buckeye Power: Columbus, OH
- Burlington Northern Railroad: Fort Worth, TX
- Butler County Rural Elec Coop: Allison, IA
- CEDA Plains Electric: Albuquerque, NM
- CMS Energy/ Consumers Energy: Jackson, MI
- CPS Energy: San Antonio, TX
- Callaway Elec Coop: Fulton, MO
- Caney Fork Electric Co-op Inc.: McMinnville, TN
- Carroll Electric Membership Corp: Carrollton, GA
- Cascade Natural Gas Corp: Seattle, WA
- Cass County Elec: Kindred, ND
- Cedar Falls Utilities: Cedar Falls, IA
- CenterPoint Energy: Houston, TX
- Central & South West Corp: El Paso, TX
- Central & South West Corp.: Dallas, TX
- Central Alabama Electric Cooperative: Prattville, AL
- Central Elec Power Co-op: Jefferson City, MO
- Central Electric Co-op Inc.: Parker, PA
- Central Electric Power Cooperative: Columbia, SC
- Central Georgia Electric Membership Corporation: Jackson, GA
- Central Hudson Gas & Elec. Corp.: Poughkeepsie, NY
- Central Illinois Light Co: Peoria, IL
- Central Indiana Power: Greenfield, IN
- Central Maine Power Company: Augusta, ME

Project New America

- Central Power & Light Company: Corpus Christi, TX
- Central Power Electric Coop: Minot, ND
- Central Vermont Public Service: Rutland, VT
- Central Virginia Electric Coop: Lovington, VA
- Cherokee Electric Cooperative: Centre, AL
- Chesapeake Energy, Arkansas: Little Rock, AR
- Chesapeake Utilities Corp.: Dover, DE
- Chicopee Electric Light: Chicopee, MA
- Choctawhatchee Elec Coop Inc: DeFuniak Springs, FL
- Choptank Electric Co-op: Denton, MD
- Chugach Electric Association Inc: Anchorage, AK
- Citizens Electric Company: Lewisburg, PA
- Citizens Gas & Coke Utility: Indianapolis, IN
- City Public Service: San Antonio, TX
- City Utilities of Springfield: Springfield, MO
- City of Anaheim - Southern CA: Anaheim, CA
- City of Anderson Light & Power: Anderson, IN
- City of Curtis Light & Water: Curtis, NE
- City of Lamar Util Board, Light & Power: Lamar, CO
- City of Riverside Public Utilities: Riverside, CA
- City of Siloam Springs Light & Water: Siloam Springs, AR
- Clairborne Elec Coop Inc.: Homer, LA
- Claremore Utilities: Claremore, OK
- Clark Energy Co-op Inc.: Winchester, KY
- Clarke-Washington Electric Co-op: Jackson, AL
- Clay Electric Co-op Inc.: Keystone Heights, FL
- Cleco Power LLC: Mandeville, LA
- Cleco Power, LLC: Crowley, LA
- Cleco Power, LLC: Pineville, LA
- Cleveland Utilities: Cleveland, TN
- Coast Electric Power Association: Bay Saint Louis, MS
- Coastal Electric Cooperative: Walterboro, SC
- Cobb Electric Membership Corp.: Marietta, GA
- Cogentrix Energy: Charlotte, NC
- Colorado Public Utilities Commission: Denver, CO
- Colquitt EMC: Moultrie, GA
- Columbia Gas of Kentucky: Lexington, KY
- Columbia Gas of Ohio - NiSource: Columbus, OH
- Columbia Gas of PA & MD: Canonsburg, PA
- Columbia Gas of VA: Chester, VA
- ComEd Economic Dev. Dept.: Chicago, IL

Project New America

- Comanche County Electric Coop Assoc: Comanche, TX
- Community Energy Inc.: Wayne, PA
- Connecticut Light and Power Co.: Hartford, CT
- Connecticut Valley Electric Inc.: East Hartford, CT
- Connexus Energy: Ramsey, MN
- Consolidated Edison: New York, NY
- Consolidated Natural Gas: Pittsburgh, PA
- Constellation Energy: Baltimore, MD
- Constellation New Energy: Louisville, KY
- Constellation NewEnergy: Boston, MA
- Constellation NewEnergy: Baltimore, MD
- Constellation NewEnergy: New York, NY
- Constellation NewEnergy: Columbus, OH
- Consumers Energy: Jackson, MI
- Continental Cooperative Services: Harrisburg, PA
- Cooke County Elec Coop Assn: Muenster, TX
- Cookeville Electric Dept.: Cookeville, TN
- Coosa Valley Electric Cooperative: Talladega, AL
- Corn Belt Power Cooperative: Humboldt, IA
- Covanta Energy: Fairfield, NJ
- Covington Electric Coop: Andalusia, AL
- Cox Communications: Phoenix, AZ
- Cox Communications: Phoenix, AZ
- Crawfordsville Electric Light & Power: Crawfordsville, IN
- Crisp County Power Commission: Cordele, GA
- Cuivre River Electric Coop.: Troy, MO
- Cullman Electric Cooperative: Cullman, AL
- Cullman Power Board: Cullman, AL
- DEMCO: Greenwell Springs, LA
- DTE Energy: Detroit, MI
- Dairyland Power Coop: La Crosse, WI
- Dakota Electric Assn.: Farmington, MN
- Dalton Utilities: Dalton, GA
- Darke Rural Electric Cooperative: Greenville, OH
- Darwin Realty & Dev Corp: Elmhurst, IL
- Dayton Power & Light: Dayton, OH
- Deaf Smith Elec Coop: Hereford, TX
- Delmarva Power: Newark, DE
- Delta Natural Gas Co. Inc.: Winchester, KY
- Denton County Elec Coop: Corinth, TX
- Detroit Edison Co: Detroit, MI
- Direct Energy: Houston, TX
- Dixie Electric Cooperative: Union Springs, AL
- Dixie Electric Membership Corp: Baton Rouge, LA

Project New America

- Dominion East Ohio: Richmond, VA
- Dominion Peoples: Pittsburgh, PA
- Dominion Virginia Power: Richmond, VA
- Douglas Electric Cooperative/
Douglas FastNet: Roseburg, OR
- Duke Energy: Hendersonville, NC
- Duke Energy: Charlotte, NC
- Duke Energy Carolinas: Duncan, SC
- Duke Energy Carolinas: Hickory, NC
- Duke Energy Co.: Greensboro, NC
- Duke Energy Indiana: Plainfield, IN
- Duke Energy Ohio/Kentucky:
Cincinnati, OH
- Duquesne Light Co: Pittsburgh, PA
- E.ON U.S.: Louisville, KY
- Eagle Energy: Houston, TX
- East Central Energy: Braham, MN
- East Kentucky Power Co-op Inc.:
Winchester, KY
- East River Electric Power Coop:
Madison, SD
- Eastern Illini Elec Coop: Paxton, IL
- Eastern Iowa Light & Power Coop:
Wilton, IA
- Easton Utilities: Easton, MD
- Echelon Corporation: San Jose, CA
- Edgecombe-Martin County Elec.
Membership: Tarboro, NC
- Edison Electric Institute: Washington, DC
- Edisto Electric Cooperative:
Bamberg, SC
- Egyptian Electric Cooperative Assn.:
Murphysboro, IL
- El Paso Electric Company (EPE):
El Paso, TX
- ElectriCities of North Carolina Inc.:
Raleigh, NC
- Electric Co-ops of Arkansas: Little
Rock, AR
- Electric Power Assn. Mississippi:
Ridgeland, MS
- Electric Power Board of Chattanooga:
Chattanooga, TN
- Electric Utility Consultants Inc.
(EUCI): Greenwood Village, CO
- Elizabethtown Gas Co.: Union, NJ
- Empire District Elec Co: Joplin, MO
- EnerStar Power: Paris, IL
- EnergyUnited: Statesville, NC
- Enstar Natural Gas Co.: Anchorage,
AK
- Entergy: New Orleans, LA
- Entergy Corporation: New Orleans,
LA
- Entergy Corporation: West Monroe,
LA
- Entergy Louisiana Inc.: Baton
Rouge, LA
- Entergy Mississippi: Jackson, MS
- Entergy New Orleans Inc.: New
Orleans, LA
- Entergy Services Inc./Gulf States
Utilities Co.: Beaumont, TX
- Entergy Solutions Ltd.: The Wood-
lands, TX
- Entergy's Teamwork Arkansas:
Little Rock, AR

Project New America

- EnviroGen LLC: Buffalo, NY
- Equitable Gas Co.: Pittsburg, PA
- Erath County Electric Co-op: Stephenville, TX
- Eugene Water & Elec Board: Eugene, OR
- Excel Energy: Denver, CO
- Exelon Corporation: Chicago, IL
- Exelon Corporation: Kennett Square, PA
- Fairfield Electric Cooperative: Winnsboro, SC
- Farmer Mutual Elec Co.: Geneseo, IL
- Farmers' Electric Co-operative: Chillicothe, MO
- Fayette Elec Coop: La Grange, TX
- Fayetteville Public Works commission: Fayetteville, NC
- First Choice Power: Fort Worth, TX
- FirstEnergy: Lebanon, PA
- FirstEnergy: Phillipsburg, NJ
- FirstEnergy Company: Red Bank, NJ
- FirstEnergy Corp: Akron, OH
- FirstEnergy Corp: Warren, OH
- FirstEnergy Corp. (GPU): Reading, PA
- Flint Energies: Warner Robins, GA
- Florida Keys Electric Cooperative Inc.: Tavernier, FL
- Florida Municipal Power Agency: Orlando, FL
- Florida Power & Light: Palatka, FL
- Florida Power & Light Energy: Juno Beach, FL
- Florida Power Corp: Altamonte Springs, FL
- Fort Hill Natural Gas Authority: Easley, SC
- Fort Pierce Utilities Authority: Fort Pierce, FL
- Four-County Elec. Power Assn.: Columbus, MS
- Frederick Gas Division: Frederick, MD
- French Broad Electric Membership: Marshall, NC
- GTE: Irving, TX
- Gainesville Regional Utility: Gainesville, FL
- Garkane Energy Power: Loa, UT
- Georgia EMC: Atlanta, GA
- Georgia Natural Gas: Atlanta, GA
- Georgia Natural Gas: Savannah, GA
- Georgia Power: Atlanta, GA
- Great Lakes Energy: Scottville, MI
- Great River Energy: Elk River, MN
- Great River Energy: Stanton, ND
- Greeley Gas Co.: Herington, KS
- Greeley Gas Company: Greeley, CO
- Green Mountain Energy Company: Austin, TX
- Green Mountain Power Corp.: Colchester, VT
- Greenville Electric Utility System (GEUS): Greenville, TX
- Greenville Utilities Commission: Greenville, NC

Project New America

- Greystone Power Corporation: Douglasville, GA
- Groton Utilities: Groton, CT
- Guadalupe Valley Elec Coop: Gonzales, TX
- Guernsey-Muskingum Elec. Co-op Inc.: New Concord, OH
- Gulf Coast Electric Coop Inc.: Southport, FL
- Gulf Coast Electric Cooperative Inc.: Wewahitchka, FL
- Gulf Power Company - Econ. Dev. Dept.: Pensacola, FL
- Gulf States Utilities: Baton Rouge, LA
- Habersham EMC: Clarkesville, GA
- Halifax Electric Membership Corp.: Enfield, NC
- Hancock-Wood Elec Coop: North Baltimore, OH
- Hart Electric Membership Corporation: Hartwell, GA
- Hawaiian Elec Co. Inc.: Honolulu, HI
- Hawaiian Electric Industries Inc.: Honolulu, HI
- Hawkins County Gas Utility: Rogersville, TN
- Heard County Water Auth: Franklin, GA
- Heartland Power Coop: Saint Ansgar, IA
- Hess Corporation: Woodbridge, NJ
- High Plains Power: Riverton, WY
- Holston Electric Cooperative: Rogersville, TN
- Holyoke Gas & Electric Dept.: Holyoke, MA
- Hoosier Energy Rural Electric Cooperative: Bloomington, IN
- Horry Electric Cooperative: Conway, SC
- Houston Lighting & Power: Houston, TX
- Hunt Power: Dallas, TX
- IES Utilities: Cedar Rapids, IA
- Idaho Falls Power: Idaho Falls, ID
- Idaho Power Company: Boise, ID
- Indian Electric Coop: Cleveland, OK
- Indiana Michigan Power Co: Fort Wayne, IN
- Indiana Municipal Power Agency: Carmel, IN
- Indiana Natural Gas Corp.: Paoli, IN
- Indianapolis Power & Light Co: Indianapolis, IN
- Iowa Assn. of Elec Coop: Urbandale, IA
- Iowa Lakes Elec Coop: Estherville, IA
- Iowa Utility Assn: Des Moines, IA
- JEA Economic Development: Jacksonville, FL
- Jackson EMC: Jefferson, GA
- Jackson Energy Cooperative: McKee, KY
- Jefferson Energy Cooperative: Wrens, GA
- Joe Wheeler EMC: Trinity, AL
- Johnson Cnty Elec Cooperative: Cleburne, TX

Project New America

- Johnson County REMC: Franklin, IN
- K.N. Energy Inc.: Scottsbluff, NE
- KC Electric: Hugo, CO
- KN Energy Inc: Hastings, NE
- KPL Gas Service: Topeka, KS
- Kamo Electric Co-Op Inc: Vanita, OK
- Kansas City Board of Public Utilities: Kansas City, KS
- Kansas City Power: Lenexa, KS
- Kansas City Power: Kansas City, MO
- Kansas City Power: Kansas City, MO
- Kansas City Power & Light: Kansas City, MO
- Kansas City Power & Light: Paola, KS
- Kansas Elec Power Co-op: Topeka, KS
- Kansas Gas & Electric: Wichita, KS
- Kenenergy Corp: Owensboro, KY
- Kentucky American Water Co. Inc.: Lexington, KY
- Kissimmee Utility Authority: Kissimmee, FL
- Koch Gateway Pipeline Co.: Lafayette, LA
- Kokomo Gas & Fuel Company: Kokomo, IN
- Koontz Electric Company Inc: Morrilton, AR
- Kootenai Elec Coop: Hayden, ID
- Korea Electric Power Corp.: New York, NY
- LA Generating LLC: Baton Rouge, LA
- Laurens Electric Cooperative: Laurens, SC
- Little River Electric Cooperative: Abbeville, SC
- Lone Star Gas Co: Dallas, TX
- Lone Star Gas Co: Farmers Branch, TX
- Long Island Power Authority: Uniondale, NY
- Lorain-Median Rural Electric Coop: Wellington, OH
- Los Angeles Dept. of Water & Power: Los Angeles, CA
- Louisiana Energy Power Authority: Lafayette, LA
- Louisiana Public Facilities Authority: Baton Rouge, LA
- Loup Power Dist: Columbus, NE
- Lower Colorado River Authority: Austin, TX
- Lubbock Power & Light: Lubbock, TX
- Lumbee River Elec Membership Corp: Red Springs, NC
- Lynches River Electric Cooperative: Pageland, SC
- MEAG Power: Atlanta, GA
- MEGACORP/City Of Mesa: Mesa, AZ
- Madison Gas & Electric: Madison, WI
- Maine & Maritimes Corporation: Presque Isle, ME
- Maine Public Service Co: Presque Isle, ME

Project New America

- Manitowoc Public Utility: Manitowoc, WI
- Maquoketa Municipal Electric: Maquoketa, IA
- Marietta Power: Marietta, GA
- Marlboro Electric Cooperative Inc.: Bennettsville, SC
- Massachusetts Energy Consumers Alliance: Boston, MA
- Matanuska Electric Association: Palmer, AK
- Mecklenburg Electric Co-op: Chase City, VA
- Memphis Light Gas and Water: Memphis, TN
- Menard Elec Cooperative: Petersburg, IL
- Meriwether Lewis Electric Co-Op: Wavery, TN
- Metro Water Dist Southern California: Los Angeles, CA
- Metropolitan Utilities District: Omaha, NE
- MichCon: Grand Rapids, MI
- Michigan Bell Econ Dev Group: Lansing, MI
- Michigan Consolidated Gas Co.: Detroit, MI
- Mid-America Pacific: West Des Moines, IA
- Mid-Carolina Electric Cooperative Inc.: Lexington, SC
- MidAmerican Energy: Sioux City, IA
- MidAmerican Energy: Urbandale, IA
- MidAmerican Energy Company: Davenport, IA
- MidAmerican Energy Company: Carroll, IA
- MidCon Power Services Corp: Lombard, IL
- Middle Tennessee Electric Membership Corporation: Murfreesboro, TN
- Middle Tennessee Natural Gas Dist.: Smithville, TN
- Midwest Gas: Des Moines, IA
- Minnesota Municipal Utilities Assoc.: Plymouth, MN
- Minnesota Power: Duluth, MN
- Minnesota Public Utilities Commission: St. Paul, MN
- Minnesotans for an Energy-Efficient Economy: St Paul, MN
- Minnkota Power Coop Inc.: Grand Forks, ND
- Mississippi Power: Gulfport, MS
- Missouri Gas Energy: Grandview, MO
- Missouri Natural Gas Co.: Farmington, MO
- Missouri Public Service: Kansas City, MO
- Montana Dakota Utilities Co.: Bismarck, ND
- Moose Lake Water & Light Comm: Moose Lake, MN
- Morgan Co. Rural Elec Assn: Fort Morgan, CO
- Mountain View Elec Assn: Falcon, CO
- Mountain View Electric Association: Limon, CO
- Municipal Energy Agency of Mississippi: Jackson, MS

Project New America

- Municipal Light & Power: Anchorage, AK
- Municipal Light & Power Elec: Woodbine, IA
- Municipality of Anchorage: Anchorage, AK
- Muscatine Power: Muscatine, IA
- Muscle Shoals Electric Board: Muscle Shoals, AL
- N.W. Electric Cooperative: Cameron, MO
- NEES Companies: Westborough, MA
- NRECA: Inver Grove Heights, MN
- NSTAR: Boston, MA
- Narragansett Electric Company: Providence, RI
- Nashville Electric Service: Nashville, TN
- Nashville Gas: Nashville, TN
- National Fuel: Williamsville, NY
- National Fuel Gas Distribution Corporation: Erie, PA
- National Grid: Syracuse, NY
- National Grid: Providence, RI
- National Grid: Salem, NH
- National Grid: Buffalo, NY
- National Grid: Northborough, MA
- National Rural Electric Cooperative Assn.: Arlington, VA
- Natural Gas Pipeline Co. of America: Lombard, IL
- Navasota Energy: Magnolia, TX
- Nebraska Municipal Power: Lincoln, NE
- Nebraska Public Power District: Columbus, NE
- Nevada Power Company: Las Vegas, NV
- New England Power Co: Concord, NH
- New Hampshire Elec. Coop. Inc.: Plymouth, NH
- New Horizon Electric Cooperative: Laurens, SC
- New Jersey Natural Gas Co: Wall, NJ
- New Jersey Natural Gas Co.: Asbury Park, NJ
- New York Power Authority: White Plains, NY
- New York State Elec. & Gas: Ithaca, NY
- New York State Electric & Gas: Lancaster, NY
- Newberry Electric Cooperative: Newberry, SC
- Newnan Utilities: Newnan, GA
- Niagara Mohawk Power Corp.: Albany, NY
- Nicor Inc.: Naperville, IL
- Noble REMC: Albion, IN
- Nolin Rural Electric Cooperative: Elizabethtown, KY
- North Arkansas Electric Cooperative Inc.: Salem, AR
- North Carolina Natural Gas: Fayetteville, NC
- North Carolina Power: Roanoke Rapids, NC
- North Carolina's Touchstone Energy Cooperatives: Raleigh, NC

Project New America

- North Central Electric Cooperative Inc.: Attica, OH
- North Dakota Assoc of Rural Elec. Co-ops: Mandan, ND
- NorthWestern Energy: Butte, MT
- Northeast Utilities: Hartford, CT
- Northeastern REMC: Columbia City, IN
- Northern Indiana Fuel & Light Co. Inc.: Auburn, IN
- Northern Indiana Public Service Company (NIPSCO): Merrillville, IN
- Northern Lightrs Community: Rapid City, SD
- Northern States Power Co: Ashland, WI
- Northern Utilities Inc., NH Div: Portsmouth, NH
- Northwest Iowa Power Coop: Le Mars, IA
- Northwest Natural Gas: Portland, OR
- Northwest Natural Gas Co.: Albany, OR
- Northwest Natural Gas Co.: Lincoln City, OR
- Northwest Natural Gas Co.: Salem, OR
- Northwest Natural Gas Co.: The Dalles, OR
- Northwestern Corp: Sioux Falls, SD
- Northwestern Rural Electric Co-op: Cambridge Springs, PA
- OG&E Electric Services: Oklahoma City, OK
- Oconee EMC: Dudley, GA
- Ohio Valley Electric Corporation: Piketon, OH
- Ohio Valley Gas Corp: Winchester, IN
- Oklahoma Electric Cooperative: Norman, OK
- Oklahoma Natural Gas Co.: Oklahoma City, OK
- Old Dominion Electric Cooperative: Glen Allen, VA
- Omaha Public Power District: Omaha, NE
- Oncor: Dallas, TX
- Orange & Rockland Utilities: Pearl River, NY
- Orlando Utilities Comsn: Orlando, FL
- Otter Tail Power Co.: Fergus Falls, MN
- Otter Tail Power Company: Fergus Falls, ND
- Owensboro Municipal Utilities: Owensboro, KY
- PECO Energy Co. Economic & Business Development: Philadelphia, PA
- PEPCO (Potomac Electric Power Company): Washington, DC
- PG Energy: Wilkes-Barre, PA
- PPL Electric Utilities: Allentown, PA
- PSNC Energy, A Scana Co.: Gastonia, NC
- Pacific Gas & Electric: San Francisco, CA
- Pacific Power & Light: Albany, OR
- Pacific Power & Light: Casper, WY
- Pacific Santa Fe Corporation: Lake Oswego, OR

Project New America

- Pacificorp: Salt Lake City, UT
- Pacificorp: Portland, OR
- Pacificorp/Utah Power: Salt Lake City, UT
- Palmetto Electric Cooperative: Hardeeville, SC
- Palmetto Electric Cooperative Inc.: Hilton Head, SC
- Palmetto Electric Cooperative Inc.: Ridgeland, SC
- Panhandle Telephone Co-Op: Guymon, OK
- Paulding-Putnam Electric Coop. Inc.: Paulding, OH
- Pea River Electric Cooperative: Ozark, AL
- Peabody Municipal Light Plant: Peabody, MA
- Peace River Electric Cooperative Inc.: Wauchula, FL
- Pedernales Elec Cooperative: Johnson City, TX
- Pee Dee Electric Coop: Darlington, SC
- Pee Dee Electric Membership Corp.: Wadesboro, NC
- Pennsylvania Power Co.: Clark, PA
- Pennsylvania Rural Elec. Assn.: Harrisburg, PA
- People's Power & Light: Providence, RI
- Peoples Energy Corp: Chicago, IL
- Peoples Natural Gas: Omaha, NE
- Peoples Natural Gas: St. Paul, MN
- Peoples Natural Gas: Hugoton, KS
- Peoples Natural Gas: Colorado Springs, CO
- Perennial Public Power Dist: York, NE
- Philadelphia Gas Works: Philadelphia, PA
- Piedmont Elec Membership Corp: Hillsborough, NC
- Piedmont Municipal Power Agency: Greer, SC
- Piedmont Natural Gas Co.: Charlotte, NC
- Piedmont Natural Gas Co. Inc.: Anderson, SC
- Piedmont Natural Gas Co. Inc.: Greenville, SC
- Piedmont Natural Gas Co. Inc.: Spartanburg, SC
- Pioneer Electric Co-op Inc.: Greenville, AL
- Pioneer Rural Electric Co-op: Piqua, OH
- Piqua Municipal Power System: Piqua, OH
- Platte Clay Electric: Kearney, MO
- Pointe Coupee Electric Membership Coop: New Roads, LA
- Portland General Electric Co.: Portland, OR
- Poudre Valley REA: Fort Collins, CO
- Powell Valley Electric Cooperative: New Tazewell, TN
- PowerSouth Energy Cooperative: Montgomery, AL
- Progress Energy: Raleigh, NC
- Progress Energy: Clearwater, FL
- Progress Energy: Florence, SC

Project New America

- Progress Energy: St. Petersburg, FL
- Providence Gas Co: Providence, RI
- Public Service Co of Oklahoma: Tulsa, OK
- Public Service Company of New Mexico: Albuquerque, NM
- Public Service Electric & Gas Co. (PSE&G): Newark, NJ
- Public Service Electric & Gas Co. (PSE&G): Hackensack, NJ
- Public Service of New Hampshire: Manchester, NH
- Puget Sound Energy: Bellevue, WA
- Questar Regulated Service Co: Salt Lake City, UT
- Qwest: Portland, OR
- Rappahannock Electric Cooperative: Fredericksburg, VA
- Reading Municipal Light Dept.: Reading, MA
- Redding Electric Utility: Redding, CA
- Reliant Energy Retail Services: Houston, TX
- Reliant Energy-ARKLA: Little Rock, AR
- Rideta Electric Co-op Inc.: Mount Ayr, IA
- Rochester Gas & Electric Corporation: Rochester, NY
- Rural Elec Coop: Lindsay, OK
- Rural Telephone Service Co. Inc.: Stockton, KS
- SCANA Corporation: Columbia, SC
- SEECO Inc. (Southwestern Energy Co.): Fayetteville, AR
- SLEMCO: Crowley, LA
- SRP Electric: Tempe, AZ
- SWEPCO: Texarkana, TX
- Sacramento Municipal Utility District (SMUD): Sacramento, CA
- Salmon River Elec Coop: Challis, ID
- Salt River Electric: Bardstown, KY
- Salt River Project: Phoenix, AZ
- San Bernard Electric Co-op Inc: Bellville, TX
- San Diego Gas & Electric: San Diego, CA
- San Luis Valley Rural Elec Co-op: Monte Vista, CO
- Sanborn Municipal Light Plant: Sanborn, IA
- Santa Fe Railway: Albuquerque, NM
- Santee Cooper Power: Moncks Corner, SC
- Santee Electric Cooperative: Kingstree, SC
- Savannah Elec & Power: Savannah, GA
- Sawnee EMC: Cumming, GA
- Schneider Electric: Palatine, IL
- Seminole Electric Cooperative Inc.: Tampa, FL
- Sempra Energy: San Diego, CA
- Shasta Lake Electric Utility: CA
- Shenandoah Gas Division: Winchester, VA
- Shrewsbury Electric & Cable Operations: Shrewsbury, MA

Project New America

- Sierra Pacific Power Company:
Reno, NV
- Silicon Valley Power: Santa Clara,
CA
- Sitara Energy Inc.: Houston, TX
- South Alabama Electric Coopera-
tive: Troy, AL
- South Carolina Power Team:
Columbia, SC
- South Central Power Co.: Lancaster,
OH
- South Kentucky Rural Electric Coop:
Somerset, KY
- South Louisiana Electric Coop Assn:
Houma, LA
- South Texas Alliance CO CP&L:
Corpus Christi, TX
- SouthStar Energy Services - Ala-
bama: Savannah, GA
- SouthStar Energy Services - Florida:
Atlanta, GA
- SouthStar Energy Services - Missis-
sippi: Atlanta, GA
- SouthStar Energy Services - Tennes-
see: Hermitage, TN
- Southeastern Illinois Electric:
Eldorado, IL
- Southern California Edison:
Irwindale, CA
- Southern California Edison: Wood-
land Hills, CA
- Southern California Gas Co: Los
Angeles, CA
- Southern Connecticut Gas Co.:
Bridgeport, CT
- Southern Minnesota Municipal
Power Agcy: Rochester, MN
- Southern Nevada Water Authority:
Las Vegas, NV
- Southern Pine Electric Cooperative:
Brewton, AL
- Southern Union Gas: Austin, TX
- Southern Union Gas Co.: Monahans,
TX
- Southwest Arkansas Water District:
Texarkana, AR
- Southwest Gas Corp: Tucson, AZ
- Southwest Gas Corp: Las Vegas, NV
- Southwest Gas Corporation: Elko,
NV
- Southwestern Electric: Greenville,
IL
- Southwestern Public Service:
Amarillo, TX
- State of Montana Public Service
Commission: Helena, MT
- Steuben Rural Electric Coop Inc.:
Bath, NY
- Sumter Electric Cooperative Inc.:
Sumterville, FL
- Suwannee Valley Electric Coop: Live
Oak, FL
- T. W. Phillips Gas & Oil Co.: Butler,
PA
- TECO Peoples Gas: Tampa, FL
- TXU Electric and Gas: Dallas, TX
- Tallapoosa River Electric Coopera-
tive: Lafayette, AL
- Talquin Electric: Quincy, FL
- Tampa Electric Company: Tampa,
FL
- Tenaska Power Services, Co.:
Arlington, TX
- Tennessee Valley Authority:
Nashville, TN

Project New America

- Tennessee Valley Authority: Muscle Shoals, AL
- Tennessee Valley Authority: Huntsville, AL
- Tennessee Valley Authority: Hickory, KY
- Tennessee Valley Authority: Knoxville, TN
- Texas Department of Transportation: Austin, TX
- Texas Electric Cooperative: Austin, TX
- Texas-New Mexico Power: Fort Worth, TX
- Texas-New Mexico Power Company: Lewisville, TX
- The Energy Cooperative: Newark, OH
- The Gas Company: Monterey Park, CA
- The Trigen Companies: Boston, MA
- The United Illuminating Co.: New Haven, CT
- Time Warner Cable: Charlotte, NC
- Tipmont REMC: Linden, IN
- Toledo Edison Co.: Toledo, OH
- Town of Ashland Elec. Dept.: Ashland, NH
- Tri-County EMC: Gray, GA
- Tri-County Electric Cooperative: St. Matthews, SC
- Tri-State Generation & Transmission Assn: Westminster, CO
- Trigen Energy Corporation: Philadelphia, PA
- Tucson Electric Power: Tucson, AZ
- Twin Valley's Public Power Dist: Cambridge, NE
- U.S. Department of Energy: Washington, DC
- UGI Electric: Wilkes-Barre, PA
- UGI Penn Natural Gas: Wilkes-Barre, PA
- UGI Utilities: Reading, PA
- URS Corporation: San Francisco, CA
- US West: Englewood, CO
- Union Pacific Railroad: Spring, TX
- Union Pacific Railroad: Westmont, IL
- Union Pacific System: Oakland, CA
- United Electric Coop: DuBois, PA
- United REMC: Markle, IN
- Unutil Systems: Hampton, NH
- Utah Power: Salt Lake City, UT
- Utah Power & Light Co.: Salt Lake City, UT
- UtiliCorp United-Headquarters: Omaha, NE
- Utilities Dist of Western Indiana REMC: Bloomfield, IN
- Utility Economic Development Association: Larchmont, NY
- VA/MD/DE Assoc of Elec Co-ops: Glen Allen, VA
- Vectren Econ Dev: Evansville, IN
- Verdigris Valley Elec Co-Op: Collinsville, OK
- Vermont Electric Cooperative: Johnson, VT
- Virginia Natural Gas: Atlanta, GA

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- Volunteer Energy Cooperative: Decatur, TN
- WE Energies: Lake Geneva, WI
- Wabash Valley Power Association: Indianapolis, IN
- Walton EMC: Monroe, GA
- Washington Gas: Springfield, VA
- Washington Gas Light Co.: Washington, DC
- We Energies: Milwaukee, WI
- Wellington Municipal Utilities: Wellington, OH
- Wellsboro Electric Company: Wellsboro, PA
- West Florida Electric: Bonifay, FL
- West Texas Utilities Company: Clyde, TX
- Westar Energy: Topeka, KS
- Western Farmers Electric Co-op: Anadarko, OK
- Western Mass. Elec. Co. - Northeast Utilities: West Springfield, MA
- Western Resources Inc.: Wichita, KS
- Westfield Gas & Electric: Westfield, MA
- Westplains Energy: Pueblo, CO
- Wharton County Elec Coop Inc.: El Campo, TX
- White County REMC: Monticello, IN
- Wild Rice Elec Coop: Mahanomen, MN
- Wisconsin Electric Power: Milwaukee, WI
- Wisconsin Pub Serv Corp: Green Bay, WI
- Withlacoochee River Electric Cooperative Inc.: Dade City, FL
- Wolverine Power: Cadillac, MI
- Woodbury Rural Electric Cooperative: Merville, IA
- Woodsville Water & Light Dept: Woodsville, NH
- Wyoming Municipal Power Agency: Lusk, WY
- Xcel Energy: Arvada, CO
- Xcel Energy: Minneapolis, MN
- Xcel Energy: Fargo, ND
- Xcel Energy: Amarillo, TX
- Xcel Energy: Minot, ND
- Xcel Energy: Lubbock, TX
- Xcel Energy: Minneapolis, MN
- Xcel Energy-Cheyenne Light: Cheyenne, WY
- Yampa Valley Elec Assn: Steamboat Springs, CO
- Yellowstone Valley Elec Coop Inc.: Huntley, MI
- York County Natural Gas Authority: Rock Hill, SC
- York Electric Cooperative Inc.: York, SC

10. New Science Industries: Nanotechnology

Jobs! Energy!

This is an area of development in which spectacular scientific breakthroughs are occurring. *Nanotechnology, biotechnology and desalination* are among new industries with extraordinary growth potential.

Nanotechnology is the engineering of functional systems at the molecular scale. It is being applied in many fields. In medicine, for example, ultra-small sensors and implants

provide both automated monitoring and semiautomatic treatment. In materials, nanotech is used to develop composite materials that are stronger, stain resistant, or fireproof.

The shrewd investors in Silicon Valley who built huge electronic empires are now funding nanotechnology energy projects and the results promise to be spectacular.

Companies in Nanotech Industries

Abbot Laboratories. Abbott Park, North Chicago, Illinois. A pharmaceuticals company with 68,000 employees in 130 countries.

Altair Nanotechnologies Inc. 204 Edison Way, Reno, NV 89502. Plasma spray coating containing titania nanoparticles.

American Pharmaceutical Partners Inc. 1501 East Woodfield Drive, Suite 300 East, Schaumburg, IL 60173. Instruments and software for diagnosis or treatment of disease.

Applied NanoWorks Inc., 9 University Place, Suite 331, Rensselaer, NY 12144. Next generation technology to produce 2nm-40nm semiconductor, metal and oxide crystals produced in water colloids.

Ardesta, LLC. 201 South Main Street, 10th Floor, Ann Arbor, MI 48104. Bringing Small

Tech and Nano Tech products to the global marketplace.

Argonide. 291 Power Court Sanford, FL 32771. Manufacturers of electro-exploded nanosize powders.

Beckman Instruments Inc. 2500 Harbor Blvd. Fullerton, CA 92634.

Bell Labs. 600 Mountain Ave., Murray Hill, N.J. 07974-0636. As part of the new Alcatel-Lucent innovation engine, Bell Labs is poised to help define the next generation of communications technology.

BioForce Nanosciences Inc. 1615 Golden Aspen Drive, Suite 101, Ames, IA 50010. Developer of ultra-miniaturized nanoarray technologies.

Calmecc (California Molecular Electronics Corporation). P.O. Box 1273, Huntsville, Ala. 35807-0273. Molecular electronics.

Carbon Nanotechnologies Inc. 16200 Park Row, Houston, TX 77084. Carbon nanotubes and films.

CarboLex Inc., 460 Parkway, Broomall, PA 19008. Carbon nanotube sales for research and industry.

Celanese Corp., 1601 West LBJ Freeway, Dallas, Texas 75234-6034. Chemicals, intermediates, filaments.

Chengyin Technology (China) Co. Ltd. No.6, Donghuan Road, Huangniupu, Shenzhen, China. Nano-structured titanium dioxide in sunscreen.

Cymbet Corp., Elk River, Minn., Manufacturing process for solid state lithium ion power sources.

Dow Chemical, Midland, Michigan, innovative drug-delivery technology, custom processing services, and functional ingredients.

eSpin Technologies Inc. (Espin). Chattanooga, TN. Producer of commercial quantity nanofibers from organic polymers.

Evident Technologies, 45 Ferry Street, Troy, New York 12180. Manufacturer of EviDots, Semiconductor Nanocrystals.

General Electric Co., Schenectady, N.Y. According to company summary, "From jet engines to power generation, financial services to security, medical imaging to eco-magination, GE is imagination at work."

Hewlett Packard and HP labs, Palo Alto, CA. Developing computers using nanowires and electrically switchable molecules. HP has built a working 64-bit memory chip in a space one micron square, so small that 1,000 could fit across a human hair.

Hielscher Hielscher Inc. 19 Forest Rd., Ringwood, New Jersey 07456. Ultrasound technology.

Hitachi. HQ, Marunouchi It chome, Chiyoda, Tokyo, Japan. A global firm with 6 corporate laboratories.

Hyperion Catalysis International Inc., 38 Smith Place, Cambridge, MA 02138. Producer of carbon nanofiber materials.

IBM Almaden Research Center. San Jose, CA. Microscopes that allow visualization as well as manipulation of materials on the scale of single atoms. IBM developed the first mass-produced commercial nanotechnology product, a disk drive head first marketed in 1997, which yielded a huge increase in disk drive data density.

Intel Corp., Santa Clara, CA. Has been manufacturing chips with silicon nanotechnology since 2000. The latest Pentium 4 processors are made up of millions of tiny transistors with a width of only 50nm (by comparison, a flu virus measures about 100nm).

Isotron Corp., 1443 N. Northlake Way, Seattle WA 98103. Nanoparticle composites.

ItN Nanovation GmbH, Untertuerkheimer Strasse 25, Saarbrucken 66117, Germany. Nanoscaled particles and ceramic parts based on nanoparticles.

Lightyear Technologies Inc., 85 Mill St., Bldg. C100, Roswell, GA. Developer of nanotechnology materials.

Luna Innovations Inc. 2851 Commerce St., Blacksburg Virginia 24060. \$2 million grant for bio-defense agent.

Mad City Labs Inc. 2524 Todd Drive, Madison, WI 53713. Positioning systems with sub-nanometer precision.

Materials Modification Inc. 2721-D Merrilee Dr., Fairfax, VA 22031. Nanopowder processes in Material Engineering.

Merck & Co. Inc., One Merck Drive, P.O. Box 100, Whitehouse Station, NJ 08889-0100. Large pharmaceutical firm with extensive research.

Mitre Corporation. A public-interest not-for-profit organization based in Bedford,

Massachusetts and McLean, Virginia. It manages federally funded research and development centers.

Molecular Manufacturing Enterprises Inc., (MMEI). 9653 Wellington Lane St. Paul, MN 55125. Founded to help accelerate advancements in the field of molecular nanotechnology.

Nanostructured & Amorphous Materials Inc., 16840 Clay Road, #113, Houston, TX 77084. Manufacturer of nanoscale powders.

Nano-Tex Corp., HQ, Emeryville, CA, with operations in Belgium; China; England; India; Italy; South Korea; and Turkey. Develops and markets nanotechnology-based textile treatments.

Nanospectra Biosciences Inc., 8285 El Rio Street, Suite 150, Houston, Texas 77054. Nano-scale optics.

Nanometrics Inc., 1550 Buckeye Drive, Milpitas, CA 95035. Develops process control metrology systems used in the manufacture of silicon and compound semiconductor substrates.

Nanocrystal Technology. (Elan Corporation plc, Dublin, Ireland). Manufactures drug delivery solutions offering enhanced absorption rates and bioavailability.

Nanocyl S.A. (Headquarters) Rue de l'Esor, 4 B-5060 Sambreville, Belgium. Produces carbon nanotubes.

Nanomaterials and Nanofabrication Laboratories (NN-Labs), PO Box 2168, Fayetteville, AR 72702-2168. Providing Colloidal Nanocrystals and Nanocrystal-Based Products.

NanoDynamics. 901 Fuhrmann Blvd., Buffalo, NY. Manufactures nanomaterials.

Nanoprobes, 95 Horse Block Road, Yaphank, NY 11980-9710. Nanogold-Streptavidin has been used for ultrasensitive *in situ* hybridization to localize viral DNA and RNA in carcinoma specimens.

Nanogen Inc., San Diego, CA. Developer of molecular and rapid *in vitro* diagnostic products.

Nanonex, 1 Deer Park Drive, Suite O, Monmouth Junction, NJ 08852. Nanoimprint lithography (NIL) tools, resists, masks.

Nano Opto. Somerset, N.J. & Orem, Utah. Densely integrated, modular nano-optic components.

Nanopierce Technologies Inc., 370 17th Street, Suite 3640, Denver, CO 80202. Nanoparticle electrical connections.

Nanomix Inc., Emeryville, CA, has developed a sensor based on carbon nanotubes that can detect chemicals down to a single molecule.

Nanologic Inc. 4295 Walnut Blvd., Walnut Creek, CA 94596. Integration of nanotechnology into computers.

NanoLab Inc. 55 Chapel Street, Newton, MA 02458. Carbon nanotubes aligned arrays and powder nanotechnology.

Nanophase Technologies Corp., 319 Marquette Drive, Romeoville, IL 60446. Markets nanocrystalline for commercial applications.

Nanosys Inc., 2625 Hanover Street, Palo Alto, CA 94304. Makes extremely small inorganic semiconductor structures, like spheres, rods or even tripods. Has a partnership with Matsushita Electric Works to market solar roofing tiles embedded with the company's nanorods. Recently, they announced a partnership with Intel.

Moore Nanotechnology Systems LLC, 426A Winchester St., P.O. Box 605, Keene, NH 03431-0605. Ultra-precision machine systems, typically utilizing Single Point Diamond Turning and Deterministic Micro-Grinding technologies, for the production of plano, spherical, aspheric, forms.

Nanochip Inc., 48041 Fremont Blvd., Fremont, CA 94538. Developing mass storage devices, based on molecular scale technology.

Nanoscale Materials Inc. 1310 Research Park Dr., Manhattan, KS 66502. Developing reactive nanoparticles.

Nanoledge. A firm of French origin now located in Canada. Produces resins that incorporate nanoparticles into composites.

Nanopowder Enterprises Inc. 120 Centennial Ave., Piscataway, N.J. Producer of specialty nanopowders.

NanoDynamics Inc. 901 Fuhrmann Blvd., Buffalo, N.Y. 14203. Nanomaterials and nanotechnology enhanced components.

Nanopowders Industries Inc., 1000 Westgate Drive, Suite 100, St. Paul, MN 55114-1067. Special alloy powders for electronic components.

Nano Products Corp. 14330 Long Peaks Court, Longmont, CO 80504. Nanomaterials.

Nanophase Technologies Corp., 1319 Marquette Dr., Romeoville, IL 60446. Nanocrystalline technology.

NexTech Materials Ltd., 404 Enterprise Dr., Lewis Center, OH 43035. Manufacturer of ceramic products for chemical, electrochemical, and electronics.

Obducat Storage AB, P.O. Box 580, SE-201 25 Malmö, Sweden. Biosensors and semiconductors.

Pacific Nanotechnology. 3350 Scott Blvd., #29, Santa Clara, CA 95054. Facilitates advances in nanotechnology and nanoresearch.

Physical Sciences Inc. (PSI), Andover, MA. The NASA Dryden Flight Research Center, Edwards, Calif., has contracted with PSI to develop an optical sensor. Firm also has contract from the National Science Foundation to develop an advanced carbon nanotube membrane for direct methanol fuel cells.

Polytec PI Inc., Auburn, MA. Piezoelectric transducers and nanopositioning equipment for scanning microscopy.

Quantum Dot Corp., 26118 Research Pl., Hayward, CA 94545. Manufactures fluorescent particles of different sizes that shine in different colors, from ultraviolet to infrared. These products are already marketed to more than 1,000 biology research customers worldwide.

SDL Queensgate Ltd. Willoughby Road, Bracknell, Berkshire, RG12 8FB, UK. Nanopositioning solutions.

Technology. 2221 Cape Cod Way, Santa Ana, CA 92703. Producer of high-quality, highly energetic ultra-pure aluminum powder at the nanoscale.

US Global Nanospace Inc. 2533 N. Carson St., Mound House, NV 89706. NanoFilter, decontamination foam and nanoscience applications.

Versilant Nanotechnologies LLC., Villanova, PA. Pioneering the invention, development, and production of nanotechnology-based materials.

Zyvex Inc., Zyvex Instruments. 1321 North Plano Road, Richardson, Texas 75081-2426. Nanotechnology development.

10. New Science Industries: Biotechnology

Biotechnology has been developed at the interface of engineering and biology, spawning hundreds of new firms.

Jobs! Energy!

For example, there are three dozen local biotech companies in Boston area and 70 in the state of Georgia. Scores of pharmaceutical companies are creating their own biotech units or setting up partnerships with bio-

tech companies. In the near future scientific breakthroughs in this field will have a significant impact in other fields, such as biomass energy production.

Companies in Biotech Industries

23andMe. Google-backed startup 23andMe, which offers a \$999 DNA scan, also said it is not violating state regulations and would continue to do business in California.

Aastrom Biosciences. PO Box 376, Ann Arbor, MI48105-9484. Developer of human cell therapy products.

Abbott Bioresearch Center, 100 Research Drive, Worcester, Mass. 01605. Pharmaceutical products.

Affymetrix Inc., Santa Clara, CA. Genome-Wide Human SNP Array 6.0. A leading genetic analysis company.

Amersham Biosciences. (see GE Healthcare Bio-Sciences Corp). Involved in gene and protein research, drug discovery and development, and biopharmaceutical manufacturing.

Amgen. Inc., One Amgen Center Drive, Thousand Oaks, CA. A leading human therapeutics company in the biotechnology industry.

Antigenics Inc., 162 Fifth Avenue, Suite 900, New York, NY 10010. Low toxicity treatments for cancers and infections.

Aquasearch. (Merged with Mera Pharmaceuticals). Specializes in the development of natural microalgae products.

Ceres Inc., 1535 Rancho Conejo Blvd., Thousand Oaks, CA 91320. The National Corn Growers Association announced that three biotech firms will begin sharing their maize or corn genome sequence data. Included are Ceres Inc., Monsanto, and DuPont subsidiary, Pioneer Hi-Bred International Inc.

Ciphergen Biosystems. 141 Wilshire Dr., Belle Mead, New Jersey 8502. Systems that

enable protein discovery, characterization and assay development.

CuraGen Corporation, 322 East Main Street, Branford, CT 06405. Protein, antibody, and small molecule therapeutics.

Evotec Inc., Suite 5, Turley Court, North Potomac, MD 20878. A leading European biotech firm, Evotec OAI, plans to locate its first North American facility at the Genome Research Institute in Reading, where it could work with GRI and companies such as Procter & Gamble Pharmaceuticals to develop new drug compounds.

Gene Express Inc., 975 Research Drive, Toledo, OH 43614, is a technology-licensing company.

GE Healthcare Bio-Sciences Corp. 800 Centennial Ave, Piscataway, NJ 08854 (formerly Amersham Pharmacia Biotech Inc. Nuclear related products: Genzyme Corporate Offices, 500 Kendall Street, Cambridge, MA 02142. Lysosomal storage disorders and other rare genetic diseases.

Geron Corporation, 230 Constitution Drive, Menlo Park, CA 94025. Diagnostic products based on common biological mechanisms underlying cancer.

Helicos BioSciences Corporation, One Kendall Square, Building 700 Cambridge, MA 02139, has sold its first DNA sequencing system, a major development for the life sciences sector. The company's DNA mapping system, called the Heliscope Sequencer, is said to be the most advanced product of its kind on the market.

Incyte Genomics Inc., 3160 Porter Drive, Palo Alto, California 94304. Its original product, LifeSeq, is a database that provides a complete and comprehensive view of the human genome.

Human Genome Sciences. 14200 Shady Grove Road, Rockville, MD 20850. Gene-based drugs.

Integrated Bio-Energy Resources Inc., 3344 Goodman Road, Southaven, MS 38672. Produces Bio-Gasoline and Bio-Diesel.

Integrated Biomolecule Corp. 2005 E. Innovation Park Dr., Tucson, AZ 85755-1966. *In vitro* diagnostics.

Maxim Pharmaceuticals Inc. (EpiCept Corporation). 3099 Science Park Rd., Ste 150, San Diego, CA 92121. Advanced therapies for cancer, infectious diseases.

MediChem Life Sciences Inc., Woodridge, IL. Drug development.

MedShape Solutions Inc., 575 14th St. NW, Atlanta, GA 30318-5455. A Georgia Institute of Technology spin-off is looking into ways to capitalize on its patented polymers technology. A grant from NIH has moved the shoulder device from an idea to a working prototype.

Mera Pharmaceuticals Inc., 73-4460 Queen Ka'ahumanu Highway, Suite 110, Kailua-Kona, Hawaii 96740. (Now includes Aquasearch, the Hawaiian company that develops nutraceutical products from aquatic plants.)

Navigenics. One Lagoon Drive, Suite 450, Redwood Shores, CA 94065. Offers clients a \$2,500 scan of their DNA for signs that they might be at higher risk for diseases such as cancer, diabetes and other ailments.

Nexia Biotechnologies Ltd. P.O. Box 187, Branch Jean-Talon, Montreal, Quebec, Canada H1S 2Z2. Manufacturer of recombinant proteins for medical and industrial applications.

Novozymes. Salem, Va., a biotech-based company and the world's largest producer of industrial enzymes and microorganisms.

Orchid Bio-Coat, a division of Orchid Orthopedic Solutions LLC. 21249 Bridge Street Southfield, MI 48034. Implant fixation.

Orchid BioSciences Inc. 4390 US Route One Princeton NJ 08540. Technologies for genetic diversity analyses.

Pioneer Hi-Bred International Inc., a DuPont subsidiary. P.O. Box 1000, Johnston IA 50131-0184. Genetic improvement of corn hybrids.

Project New America

Procter & Gamble Pharmaceuticals Inc. One Procter & Gamble Plaza, Cincinnati, Ohio 45202. A wide range of prescription products.

Sanofi-aventis, Tucson, AZ. French drug-maker Sanofi-aventis is building a new research lab in the same technology park where Ventana is headquartered.

Serono Group. (Merck). Developer of pharmaceutical products.

TransMolecular Inc., 840 Memorial Drive, Second Floor, Cambridge, MA 02139. A biotechnology company committed to discovering targeted therapies for aggressive cancers.

Ventana Medical Systems, 1910 Innovation Park Dr., Tucson, AZ 85755. With a large and growing worldwide install base, Ventana's advanced technologies have introduced consistent and reproducible quality staining results to laboratories throughout the world.

10. New Science Industries: Desalination

Water is the world's most important product. The demand is skyrocketing. One day soon water will be the world's biggest business.

Jobs! Energy!

With water shortages looming across the country, it's time for many areas to commit to seawater desalting plants, select sites, and plan distribution routes. Prompt action can bring new rivers of fresh water and avert disasters.

I have seen the results in Kuwait, Bahrain, Qatar, the UAE, Oman and Saudi Arabia. Where once there were bleak villages on barren desert sites there are now bright modern cities with tree-lined streets. There are homes with lush gardens. In the countryside there are productive farms.

I have visited the big desalting plant at Jubail, Saudi Arabia – a world model. I have seen the pipeline that carries a river of fresh water 200 miles (322 km) inland to the capital city of Riyadh. I know from personal observation that desalted seawater has given a large region an entirely new future filled with opportunities. How can we not be impressed?

Certainly, desalted seawater is no secret. There are thousands of desalination plants, mostly small ones, in operation around the world. About two thirds are located in the Middle East and others are scattered across islands in the Caribbean and else

where. Citizens of Aruba, for example, boast about their high-tech water. I visited their plant that has for many years met the needs of a thriving tourist industry.

The largest plant in the United States is the pioneering \$158 million project of the Tampa Bay Water agency. The project was let to contract in 1999, and after overcoming some technical problems in its early years, is now performing well. Veteran wetlands consultant Robin Lewis has found no significant environmental problems.

A challenge for water officials

As yet no U.S. water agency has undertaken a really big project comparable to those found along the Arabian Gulf. However the time has come for that kind of planning. The first obstacle is cost. We're talking about multi-billion dollar projects. Desalted seawater is expensive today and it will take time for improving technology to bring the cost down. That will give timid government officials and politicians excuses to delay action. Many will drag out the planning process for years during which the cost of a plant and related distribution facilities may double or triple.

Fuel is a major factor. Desalt plants in the United States don't have access to cheap oil as do those plants in the Middle East. Planners of big new units in the Western United States need to think of energy from wind and solar installations. Along the Florida coast, ocean energy could become important. The Gulf Stream is an enormous asset waiting to be used. Electric utilities that need cooling water may joint-venture such undertakings.

Today plans are underway in California for a seawater desalting plan to meet about one-half of the water requirements of Santa Barbara. A group that includes Bechtel and several utilities has proposed to build a desalting plant near San Diego to produce 100 million gallons (378,541,178 l) per day of potable water. A private developer has built a small plant on Catalina Island. North of San Francisco, Marin County is considering a seawater unit.

Texas is also active. A \$2 million pilot plant has been built at Brownsville to explore ideas for a \$150 million installation planned for 2010.

Obviously, coastal states have a big advantage in coping with future water needs. There are many cities sitting at the ocean's edge and many more nearby. There will be major problems with inland cities. Sooner than we think it will be necessary to build pipelines to some of them. Right now Las Vegas is planning a \$2 billion, 300-mile (483-km) pipeline to bring water from rural northeast Nevada counties to the city.

Booming Orlando has been expecting to meet future water needs by piping water from the St. Johns and other rivers in northern Florida. However, this scheme is strongly opposed by ecologists. After the expensive environmental mistakes of the cross-Florida barge canal and manipulation of the Everglades, the state may be hesitant to approve any more drastic changes in natural flow patterns.

Thus, Orlando could be the first large inland city in Florida to resort to a seawater system, as difficult as that might be. There would be powerful opposition to building a large desalting plant at the nearest point on the East Coast where it might conflict with the NASA launch complex. An offshore site might work.

Atlanta's water problems

I am astonished to report that at this moment the Atlanta area is threatened with a water crisis. Way back in the 1950s I was chairman of the planning commission in DeKalb County, then the fastest-growing entity in the Atlanta metro area. In the '60s I served two terms in the Georgia Senate, dealing with current and impending problems. Later I was chairman of the Georgia Science and Technology Commission, which received planning studies from groups of experts. In none of these positions did I ever hear of a possible long-term water shortage for Atlanta.

What happened? A population explosion accompanied by an extended drought of unprecedented severity has lowered water levels drastically in Lake Lanier and Lake

Allatoona – two huge reservoirs serving the area. Will Atlanta, 300 miles (483 km) from the ocean, someday have to turn to seawater?

Long-range climate forecasts predict such water shortages for many cities throughout the nation. These problems can only be solved via expensive new systems that require years to plan and build. This is not easy to sell. Politicians prefer short-range projects. They want to pose cutting the ribbon opening the new highway before they come up for re-election. Projects that can show nothing but a big muddy hole in the ground at election time are not so popular.

Long delays are also very expensive. In the 1960s I was co-author of the senate bill launching MARTA, the Metropolitan Atlanta Rapid Transit Authority. It was a very timely move. Unfortunately the officials involved did not get actual construction underway until about 10 years later. During that time high-rise buildings were located in the planned right-of-way and the cost more than doubled.

It will be interesting to see which corporations and areas in the United States seize the opportunity to lead in developing seawater systems. We will also be watching to see if new “Aqua Cities” built around desalting plants bring new life to sites in the Sonora, Atacama, and Sahara deserts – as we proposed in our trilogy *Three Tomorrows* in 2004.

Looking far ahead

Will large numbers of seawater desalting plants cause new problems? Of course they will. All big projects

bring headaches. However, the desalting plants that could in each case raise site problems may in the aggregate solve a huge global problem – the rise of sea levels due to global melting. Building desalting plants may offer a better way to achieve sea level balance!

For some time the world has been in a warming cycle. A lot of water long trapped in polar ice caps, glaciers, and tundra is being freed as melting occurs. If this trend continues the sea level may increase enough to flood coastal areas – including major cities.

Some people are already in a panic about this possibility. Even conservative analysts agree that there is a potential problem. Some corporate facility planners are beginning to wonder about locating new plants at coastal sites. Some scholars say flooding will be a big factor in 20 years. (Others say 50 or more.)

What to do? One school of thought is that the problem can be solved by building dikes to protect cities and other assets. They point to the impressive dike system built by The Netherlands to protect a large land area previously flooded by the North Sea. This is very expensive. It would consume resources needed to sustain growing populations. Damage to salt marshes and other vital environmental assets would be enormous. However, if the need were desperate enough, the dikes could be built. We are intrigued by another possible solution: The people of the world don't have enough drinking water. Deserts are expanding and, despite efforts to reduce waste of existing

water – plus drilling deeper into aquifers – many cities in non-desert areas are facing critical water shortages. For many areas this is not a future problem – it is already here.

There is only one place the world can go to find the water it needs – the oceans. Along the Arabian Gulf such nations as Kuwait, Saudi Arabia, Bahrain, Qatar, the UAE and Oman have shown the way. They have built sea water desalting plants and created new sources of potable water for cities, industries, and farms.

Some of the newest and largest desalting plants in the region can process a billion gallons per day. Compare that with the estimated 50 billion gallons per year that flow into the ocean from the melting Greenland ice pack.

We don't know the net effect of a desalting plant on the sea level. We know that some very salty water is

returned to the sea. However, most of the product of a desalting plant is widely distributed on shore among people, plants and processes. Some eventually goes into the atmosphere via transpiration.

Is it possible, we ask, for desalting plants to be a factor in controlling the sea level? We are not talking about one or two big plants. The world is going to need hundreds of plants. Moreover, bigger plants of the future may each process two or three billion gallons per day. We believe a hundred such plants might draw enough water from the oceans to minimize the flooding threat.

Instead of building dikes that serve no purpose other than flood control, the world could build desalting plants that would bring deserts to life and enhance the quality of life of billions of people – clearly a better investment!

Some Significant Water Projects Around the World

Australia

With the official opening of the **Perth Seawater Reverse Osmosis Plant** in 2006, Western Australia became the first state in the country to use desalination as a major public water source – and this may be simply the beginning. Facing a drying climate, the Water Corporation of Western Australia is actively exploring a variety of options to meet growing demands, which makes building a second SWRO facility a serious prospect to consider.

Located at Kwinana, some 16 miles (25 km) south of the city, the new plant has an initial daily capacity of 140,000m³ with designed expansion to 250,000m³/day, making it the largest of its kind in the Southern Hemisphere and the biggest in the world powered by renewable energy.

Saudi Arabia

One of the most interesting projects in the nation is **King Abdullah Economic City** (KAEC) located on the Red Sea coast. Reportedly a key element will be a 30,000m³/day membrane bioreactor (MBR) plant. The treated water will be used for landscaping as well as for the golf courses at KAEC.

United Arab Emirates

Fujairah, one of the seven emirates, has a desalting plant that produces

100 million gallons of fresh water a day. Water from the **Fujairah plant** is piped 186 miles (300 km) south to Al Ain, the country's fourth largest city near the Oman border.

The Fujairah plant was the biggest in the region until Saudi Arabia built its newer **Shuaibah project**.

The commercial hub of Dubai and the capital of Abu Dhabi are supplied partly with water from another desalination plant built by Doosan Heavy Industries at **Jebel Ali**.

Doosan is also building desalination and power generation plants in the port city of **Sohar, Oman**, 155 miles (250 km) northwest of the capital, Muscat. Once a sleepy fishing village, Sohar is becoming a thriving industrial town with a refinery.

Viet Nam

Hoa Binh – Viet Nam's largest water supply plant is the 600,000m³/day-capacity Song Da plant. The US\$161 million project is part of a new water system that will supply the northern mountainous province of Hoa Binh, the Red River Delta Province of Ha Tay and Ha Noi. By 2010, the capacity will rise to 400,000-450,000m³ of water for Ha Noi and 150,000-200,000 m³ for a series of cities and industrial zones west of Ha Noi. The plant is expected to raise its water supply capacity to 1.2 million m³ a day by 2020.

Some Significant Water Plants in the United States

While it has no match for the big desalting projects along the Arabian Gulf, the United States has a number of large-scale water projects in place or under construction. As yet, there are just a few desalting plants scattered among many facilities for conventional water treatment. Also to be noted are new science approaches to water treatment, such as membrane bioreactors. A significant pioneering unit is nearing completion in Seattle.

California

A unit of General Electric Company has announced its participation in what will be the largest seawater desalination facility in North America, the **Carlsbad Seawater Desalination Plant**. GE Water & Process Technologies, Poseidon Resources Corporation, American Water and Acciona Agua have joined to invest in a 50-mgd desalination project in San Diego County. The plant can produce enough drinkable water to meet the needs of about 220,000 families.

Illinois

Chicago's **James W. Jardine Water Purification Plant** is believed to be the largest water treatment plant in the world. It processes about one billion gallons of water per day.

New York

New York City's Department of Environmental Protection is building one

of the largest **water filtration plants** in the world in a 10-story-deep hole it blasted out of bedrock in the Bronx. When completed in 2012, the plant, capable of purifying 300 mgd water, will be buried there. The cost is now estimated at nearly \$3 billion, a huge jump from the \$660 million city officials estimated when they announced the plan in 1998.

Texas

Private investors are getting involved in new water projects in the United States. An example is the **Northeast Water Treatment Plant** in Houston. The public partner is the Houston Area Water Corp. (HAWC), created by the City of Houston. Montgomery-Watson-Harza (MWH) was chosen as the private partner. MWH designed and built the 40 mgd water supply facility and will sell the water to HAWC.

Companies in Water Industries

Water treatment is already a huge industry. The segment that now promises to grow explosively is desalination. New technology will soon bring the cost down and create opportunities for launching scores of new plants.

ABS Group. Head Office, Roskildevägen, Box 394, 201 23 Malmö, Sweden. Production facilities in Sweden, Germany, Ireland and Brazil. Manufacturer of pumps, mixers and aerators for wastewater and water applications.

A-C Pump, a division of ITT Corporation, manufacturers of centrifugal pumps and parts for the global industrial and municipal markets. ITT - Goulds Pumps HQ, 240 Fall St., Seneca Falls, New York 13148.

Akiki Engineering Ets. Achrafieh, Saide St., El-Madonna Bldg., Beirut, Lebanon. Water treatment and chemical treatment, hydronic systems.

Alstom Power S.A. 1: 4 Avenue André Malraux City Town: Levallois Perret Post Code: 92309, France. Involved in a huge project for Emirate of Fujairah. Power plant and desalination plant combined.

American Pacific Corporation (AM-PAC), 3770 Howard Hughes Parkway, Suite 300, Las Vegas, NV 89169. Designs and builds in-space propulsion systems, thrusters and propellant tanks. Also manufactures water treatment equipment for odor control and water disinfection.

Amphion International. 275 13th St. NE Atlanta, GA. A water treatment system that sterilizes surface drinking water, wastewater, and reuse water.

Anco Pumps. 248/250, Abdul Rehman Street, Mumbai 400 00, Maharashtra, India. Manufacturer of centrifugal pumps and motors, including self-priming and submersible models.

Anderson Chemical Company Inc. 1840 Waterville Rd., Macon, GA 31206-

1146. Specializing in water treatment applications for boiler systems, cooling water systems, ion exchange, water conditioning, and waste water treatment.

Aqua Science Inc. 1601 Woodland Avenue, Columbus, Ohio 43219-1135. Water supply and treatment equipment and supplies.

Aquatech International Corp. Canonsburg, PA. Industrial water treatment equipment and wastewater treatment equipment.

Asa Proses Environment Construction Co. DOSB 232 Parsel, Gebze, Kocaeli, 41400, Turkey. Water & Wastewater Treatment Equipment & Systems.

Bechtel Corporation. San Francisco. One of the largest engineering companies in the world. Some 40,000 employees in 50 countries with \$20 billion in revenue. Leon Awerbuch, manager of desalting and power programs.

Besco Water Treatment Inc. 29th St. SE, Grand Rapids, MI 49508. Water treatment. residential and commercial equipment.

Black and Veatch. Overland Park, Kansas. Firm has more than 9,600 professionals working in more than 100 offices worldwide with water and energy projects in 70 countries.

Blue Steel Water Purification Co. No. 4, Jalan BS 7/19, Kawasan Industri Bukit Serdang, 43300 Seri Kembangan, Selangor Darul Ehsan, Malaysia. Commercial and domestic water treatment.

Core-Rosion Products, 3395 E. 19th St., Signal Hill, CA 90755. Polyethylene tanks,

fiberglass tanks, dual laminate tanks, polypropylene tanks, UL storage tanks, level controls, mixers.

Crane Environmental Inc. 730 Commerce Drive, Venice, FL 34292. Manufacture water treatment equipment, membrane-based water purification systems.

Culligan International, 9399 W. Higgins Road, Suite 1100, Rosemont, IL 60018. Manufacturer of water treatment systems.

Dimanco Ltd., Unit 24, Henlow Trading Estate, Henlow, Bedfordshire, SG16 6DS, U.K. Produces water testing equipment, water contamination and filtration treatment systems.

Donamarc Water Systems Co., 569 East Turkeyfoot Lake Rd. Akron, Ohio. Water treatment systems for industrial, manufacturing, commercial.

Doosan Heavy Industries & Construction Co. Ltd. 555, Guygok-dong, Changwon-City, Kyongnam, South Korea. Said to be the world's No. 1 desalination plant builder with 1.38 million tons per day in total capacity contracted.

Doosan Hydro Technology, 912 Chad Lane, Tampa, FL 33619. The U.S.-based subsidiary of Doosan Heavy Industries & Construction.

EMU Unterwasserpumpen. German manufacturer of submersible pumps for drinking and industrial water supply, for dewatering and wastewater treatment.

Envirogard Malaysia Sdn. Bhd., Lot 19, Jalan PJS 11/16 Bandar Sunway, 46150 Petaling Jaya, Selangor Darul Ehsan Malaysia. Wastewater equipment, supplies and services.

Everfilt, 3167 Progress Circle, Mira Loma, CA 91752. Global manufacturer of turnkey water & wastewater filtration treatment systems.

Florida Water Processing, 1086 N.W. 53rd Street, Ft. Lauderdale, FL 33309. National distributors of water treatment equipment.

Gordon Brothers Water. 776 N. Ellsworth Ave. P O Box 358, Salem, OH 44460. Water treatment and conditioning equipment and supplies.

GET Inc. (Global EnviroScience Technologies), PO Box 90756, Long Beach, CA 90809-0756. Reverse osmosis sea water desalination.

Gorman-Rupp Company, P.O. Box 1217, Mansfield, Ohio 44901-1217. Manufactures pumps and pumping systems for industrial water, wastewater, and sewage.

Goulds Pumps, ITT Corp., 2881 East Bayard Street, Seneca Falls, NY 13148. Manufacturer of pumps and systems for water and wastewater technology applications.

Great Water Company, 1605 Sudderth Drive, Ruidoso, NM 88345. Reverse osmosis drinking water systems for residential or commercial applications.

H.I. Fraser Pty Ltd., Warriewood, New South Wales, Australia. Hyperbaric specialist supplying Australian industry for past 50 years.

High Peaks Water Services Inc. P.O. Box 7150, Phoenix, Arizona 85011. Water treatment and water filtration systems.

HCP Pump Manufacturing Co. Ltd. No. 7, Kung Yeh 4th Rd., Ping-Tung, Taiwan. Manufacturer of submersible sewage and wastewater pumps.

Huzhou Storm Water Treatment Equipment Co. Ltd., 11 Huichengbei Road, 1st District of North Town, Huzhou, Zhejiang, China. Design and construction of water treatment facilities.

HydroMax, PO Box 1207, Emmitsburg, MD 21727. Seawater desalination systems, wastewater treatment and recycling systems.

Hydroflow Filtration Systems. (The Andersons Inc.). P.O. Box 119, Maumee, OH 43537. Global supplier of water purification & filtration equipment.

Hyundai Engineering & Construction. 140-2, Kye-dong, Jongno-gu, Seoul, 110-793, South Korea. Construction of petrochemical

plants, power generation and desalination plants, nuclear power plants and industrial and environmental plants

IDRECO. Via Pietro Nenni, 15 - 27058 - Voghera (PV), Italy. Industrial wastewater & water treatment equipment.

Industrial Water Equipment Ltd. 124 / 126, North Parade, Matlock Bath, Derbyshire, DE4 3NS, UK. Manufacturer of water filtration and reverse osmosis equipment.

Impregilo. Viale Italia, 1, Sesto San Giovanni, 20099 Milan, Italy. A large global builder of desalination and water treatment plants.

Industrial Water Services Inc. 1640 Talleyrand Avenue, Jacksonville, FL 32206. Operates several industrial waste/used oil processing facilities.

Industrial Water Services. 4500 Turf Rd., El Paso, TX. Water filtration, reverse osmosis systems.

Ionics Inc., 65 Grove St., Watertown, MA 02472. Synthetic membranes used to filter salt from water. Reported to be designing desalination plant for Santa Barbara.

Kemira Water Solutions Inc., 808 E. Main Street, Lakeland, Florida 33801. Producer of water treatment chemicals including polyaluminum chloride, aluminum sulfate and sodium aluminate.

KK Water Purification Ltd., Victory House, Victory Park Road, Addlestone, KT15 2AX, Surrey, UK. Providers of water treatment and water recycling equipment.

Megahome Corp., No.24, Lane 44, Ping Feng Road, Tai-Nan City, Taiwan 708. Manufacturer of water treatment equipment.

Milieu-nomics Inc. 100 Bridge Street, Wheaton, IL 60187. Water and wastewater treatment products.

Mitsubishi Heavy Industries Ltd. 16-5, Konan 2-chome, Minato-ku, Tokyo 108-8215, Japan. Global firm that produces desalination plants plus many others.

MWH (Montgomery-Watson-Harza), 380 Interlocken Crescent, Suite 200, Broomfield, CO 80021. Energy and environmental engineering, construction, and water resource management firm.

Nelsen Corporation, P.O. Box 1028, 3250 Barber Rd., Norton, OH 44203. Water systems, sump, sewage, and water treatment equipment.

Organo Corporation, 1-2-8 Shinsuna, Koto-ku, Tokyo, Japan, manufacturer of water treatment equipment.

Pentek/Pentair Water Co. 293 Wright St. Delavan, WI 53115. Water treatment equipment.

Puraq Company, Stamford, Conn. Reports development of a process to separate potable water from salt water with a chemical solvent.

Pure-Aqua Inc., 15 Hammond St., Irvine, CA 92618. Reverse osmosis systems, water treatment.

Res-Kem Corp., PO Box 1059, Media, PA 19063. Manufacturer of water treatment equipment.

Saline Water Conversion Corporation (SWCC), P.O. Box 5968, Riyadh 11432, Saudi Arabia. A world leader in construction of seawater desalination plants.

Sanitaire Water Treatment (ITT Sanitaire), 9333 N. 49th Street, Brown Deer, WI 53223. Waste water treatment technologies for municipal and industrial facilities.

A. Siniaver & Co. Engineers Ltd., 3 Moshe Hes St., West Industrial Area, Lod, Israel, 71201. Centrifugal pumps and waste water treatment equipment.

SNC-Lavalin Group, Montreal, Quebec, Canada. One of the world's largest engineering firms.

SpectraPure Inc., 2167 E. 5th Street, Tempe, AZ. Pumped RO Systems, Reverse Osmosis, Deionization Systems, Water Softener.

Project New America

Trombold Equipment Co., 3030 McKinley Ave, Columbus, OH 43204. Sewage pumps, fire pumps.

Ultrapure, 1175 Appleby Line, Unit B2, Burlington, ON L7L 5H9, Canada. Pure water applications.

USFilter, Wallace & Tiernan products, 1901 West Garden Road, Vineland, New Jersey 08360. Part of the Siemens group. Water treatment systems.

Vital Living Products, Inc. (division of American Water Service), 5001 Smith Farm Rd., Matthews, NC 28104-8134. Water treatment products and services.

Western Pump Co., 3235 F St., San Diego, CA 92102. Water treatment equipment.

WaterKing Inc. 102 Charbonnet Rd., Lafayette, LA. Water treatment systems.

Watts Water Technologies Inc. 815 Chestnut Street, North Andover, MA 01845-6098. Manufacturer of water purification equipment.

Xypex Chemical Corp. 13731 Mayfield Place, Richmond, BC, Canada V6V 2G9. Waterproof coatings for concrete.

Yardney Water Management Systems Inc. 6666 Box Spring Blvd., Riverside, CA. Water filtration systems for removal of toxins, odor, suspended solids and taste.

Zenon Environmental Inc. (GE Water & Process Technologies), Oakville, Ontario, Canada.

13. Nuclear Power Industries

Nuclear power is important and will be for the foreseeable future. A typical nuclear power plant produces about 1,000 MW. With multiple reactors, some plants produce 3,000 MW.

Jobs! Energy!

The United States was the world leader in the development of nuclear power. Following World War II, we developed nuclear power plants for submarine and aircraft carrier propulsion units as well as electric generating stations for commercial use. Several dozen significant plants – enough to supply 20 percent of our energy needs – operated safely and successfully before the accident at Three Mile Island.

That incident led to strong public resistance to new nuclear projects and the United States has not built a nuclear power plant for 30 years. Meanwhile nuclear power has spread around the world. France now gets more than 75 percent of its electric

energy from nuclear plants. China has embarked on a very ambitious construction program that involves 50 nuclear units. Around the world there are some 435 nuclear plants operating in 30 nations. Even the oil-rich United Arab Emirates has announced a nuclear energy program.

Now, key utilities in the United States are proposing to build a total of 30 new reactors. This revival is spurred by urgent energy needs, higher prices for competitive systems, and less restrictive regulations. The construction of these units will provide many new jobs in the industry. An estimated 1,500 subcontracting and supply firms are involved.

Nuclear Power Plants in the United States

According to the U.S. Energy Information Administration there are now 103 licensed power reactors at 65 plant sites.

- Alabama: Browns Ferry, Farley
- Arizona: Palo Verde
- Arkansas: Arkansas Nuclear One
- California: Diablo Canyon, San Onofre
- Connecticut: Millstone
- Florida: Crystal River 3, St Lucie, Turkey Point
- Georgia: Hatch, Vogel
- Illinois: Braidwood, Byron, Clinton, Dresden, LaSalle County. Quad Cities
- Iowa: Duane Arnold
- Kansas: Wolf Creek
- Louisiana: River Bend, Waterford
- Maryland: Calvert Cliff
- Massachusetts: Pilgrim
- Michigan: Donald C. Cook, Enrico Fermi, Palisades
- Minnesota: Monticello, Prairie Island
- Mississippi: Grand Gulf
- Missouri: Callaway
- Nebraska: Cooper, Fort Calhoun
- New Hampshire: Seabrook
- New Jersey: Hope Creek, Oyster Creek, Salem Creek
- New York: Fitzpatrick, Indian Point, Nile Mile Point, R.E. Ginna
- North Carolina: Brunswick, McGuire, Shearon-Hams
- Ohio: Davis-Besse, Perry
- Pennsylvania: Beaver Valley, Limerick, Peach Bottom, Susquehanna, Three Mile Island
- South Carolina: Catawba, H.B. Robinson, Oconee, Summer
- Tennessee: Sequoyah, Watts Bar
- Texas: Comanche Peak, South Texas
- Vermont: Vermont Yankee
- Virginia: North Anna, Burry
- Washington: Columbia
- Wisconsin: Kewaunee, Point Beach

Companies in Nuclear Industries

A cross-section of firms engaged in uranium mining and processing, reactor design, nuclear power plant construction, spent fuel disposition, and related services.

AMEC NNC, 76 - 78 Old St., London EC1V 99RU, UK. Nuclear plant engineering.

Amer Industrial Technologies Inc. (AIT). 100 Amer Rd. Bldg. 200. Wilmington, DE 19809. Nuclear heat exchangers, heavy walled vessels, tanks, and filters.

Anglo American plc. 20 Carlton House Terrace, London SW1Y 5AN, United Kingdom. A global mining firm. Uranium.

Ansaldo Nucleare. Corso Perrone 25 – 16161 Genova, Italy. Builds nuclear power plants.

Areva, 33, rue La Fayette, 75 442 Paris Cedex 09, France. A world leader in uranium mining, conversion and enrichment through spent fuel reprocessing. Areva NP. The La Hague Reprocessing Plant treats spent nuclear fuel from France, Japan, Germany, Belgium, Switzerland, Italy and The Netherlands. **SGN** is an Areva nuclear engineering subsidiary.

Atomic Energy of Canada Ltd., Sheridan Park, 2251 Speakman Drive, Mississauga, Ontario, Canada L5K 1B2. Manufacturer of nuclear power reactors.

Atomtex. 5 Gikalo Street, Minsk 220005, Republic of Belarus. Manufacturer of instruments and equipment for nuclear measurements and radiation monitoring.

Atomstroyexport. A Russian nuclear firm based in Moscow. Is building seven nuclear reactors – in Iran, China, Bulgaria and India – a higher number of reactors, it states, than any competitor.

Babcock & Wilcox Co., 800 Main Street, 4th Floor, Lynchburg, VA 24505. (BWXT Technologies Inc.). Manufacturer of nuclear materials and nuclear reactor components. The company has manufactured more than 200 nuclear steam generators.

Bechtel Corp., San Francisco. A leader in construction and operation of nuclear power plants.

Belgonucleaire S.A. 4, avenue Ariane, B-1200 Bruxelles, Belgium. Manufacturer of mixed oxide fuel (MOX) for nuclear power plants.

Bluerock Resources Ltd., Nanaimo, BC, Canada. Uranium mining.

British Nuclear Fuels plc (BNFL). Daresbury, England. Manufactures and transports nuclear fuel, runs reactors, generates and sells electricity. Affiliated: BNFL & Westinghouse Japan.

British Energy Group Plc., GSO Business Park, East Kilbride G74 5PG, UK.

Cameco Corp., Saskatoon, Saskatchewan, Canada. The world's largest publicly traded uranium company.

Ceske Energeticke Zavody (CEZ). The major power provider in the Czech Republic.

Chase Environmental Group. 109 Flint Rd., Oak Ridge, TN 37830.

China National Nuclear Corporation (CNNC), P.O. Box 2102, Beijing 100822, China.

Chugoku Electric Power Co. Inc. 4-33, Komachi Naka-ku, Hiroshima 730-91, Japan.

Chubu Electric Power Co., 1 Higashi-shincho, Higashi-ku, Nagoya 461-8680, Japan.

Cogema (See Areva)

Cotter Corp., 12596 West Bayaud Ave., Suite 350, Lakewood, CO 80228. Operates uranium mill.

Cremat Nuclear Electronics, 45 Union St., Watertown, MA 02472. Manufacturer of charge sensitive preamplifiers for radiation detection.

Denison Mines Corp., Atrium on Bay, 595 Bay Street, Suite 402, Toronto, Ontario M5G 2C2, Canada. Uranium exploration, mining, and milling.

DIAMO s.p., Máchova 201 Stráž pod Ralskem 471 27, Czech Republic. Mining.

Doosan Heavy Industries & Construction Co. Ltd., Chamgwon, South Korea. Has built 15 nuclear power plants around the world and has six more under construction.

Duke Energy, Charlotte, NC, has assets in the United States, Canada and Latin America. **Duke Cogema Stone & Webster** (DCS) is a consortium providing services to the U.S. Department of Energy.

E.ON Kernkraft, Hannover, Germany. Europe's largest private-sector energy firm.

E.ON Sverige, AB. Stockholm. Energy firm in Sweden.

Electrabel, Brussels, Belgium. Operates nuclear plants Doel and Tihange.

Electricite de France, 22-30 Ave. de Wagram, Paris 75382, France. State-owned utility serving France.

Eletronuclear. Rua da Candelária, 65 – Centro, CEP: 20091-906. Brazil. Operates nuclear plants.

EnBW Kraftwerke Energie, Baden-Württemberg AG 2008. Germany.

Energatom. Kiev, Ukraine. Construction of new power units and rehabilitation of those in operation, purchase of the new nuclear fuel and removal of radioactive waste.

Energy & Process Corporation. Supplier of nuclear pipe, valves, fittings and structural steel products for the nuclear industry. www.energyandprocess.com

Energy Resources of Australia Ltd., Level 10, TIO Centre, 24 Mitchell Street, GPO Box 2394, Darwin 0801, NT, Australia. Exports uranium oxide to nuclear utilities in Asia, Europe and North America.

Encapsulation Technologies. 3150 E. Pico Boulevard, Los Angeles CA 90023. Has developed a process that eliminates airborne radioactivity and fixes contamination remotely without the need for people or equipment to enter contaminated areas.

Equipos Nucleares, SA (ENSA). Madrid, Spain. Manufacturing: Production of steam generators for nuclear power stations; components for nuclear plants and equipment for radioactive waste treatment.

Eskom. Megawatt Park, Maxwell Drive, Sunninghill, Sandton. South Africa.

Eurodif, SA. 4, rue Paul Dautier, BP 35, F-78142 Vélizy-Villacoublay, France.

Exelon Corp., 10 South Dearborn Street, 48th Floor, P.O. Box 805398, Chicago, IL 60680-5398.

Florida Power and Light Group (FPL). FPL Energy has 88 percent ownership of the Seabrook Station in New Hampshire; a 70 percent interest in the Duane Arnold Energy Center in Iowa; and 100 percent ownership of Point Beach Nuclear Plant in Wisconsin.

General Atomics, P.O. Box 85608, San Diego, CA 92186-5608. Radiation monitoring systems.

General Electric Inc. Schenectady, N.Y. Four main product lines in the nuclear field include: new reactors, nuclear fuel, reactor services and performance services. **Global Nuclear Fuel (GNF)**. A joint venture of General Electric, Hitachi, and Toshiba for supply of nuclear-fuel.

Hokkaido Electric Power Co. Inc., 2, Higashi 1-chome, Ohdori, Chuo-ku Sapporo, Hokkaido 060 8677, Japan.

InfoMine Inc., Suite 640, 580 Hornby Street, Vancouver BC, Canada V6C 3B6. Uranium.

INVAP (Rio Negro state company for applied research), Bariloche, Argentina. Equipment for the nuclear fuel manufacturing industry

Ishikawajima-Harima Heavy Industries Co. Ltd (IHI), Tokyo, Japan. Primary components for nuclear power plants.

Isotope Technologies. 99, Krasin str., Minsk-Sosny, 220109 Belarus. Manufacturer of radiation devices and exporter of radionuclide products.

KazAtomProm., Bogenbai Batyr Street 168, 480012 Almaty, Kazakhstan. A world leader in uranium.

Mitsubishi Heavy Industries Ltd (MHI), 16-5, Kounan 2-chome, Minato, Tokyo 108-8125, Japan. One of the world's leading manufacturers of heavy machinery including a number of nuclear power plants.

Mohr and Associates Inc. (MA). 76 Wellsian Way, Richland, WA 99352-4111. Nuclear and chemical process instrumentation.

NUCLEP (Nuclebras Equipamentos Pesados) SA, Brazil. Makes heavy components for Brazilian nuclear power plants.

Numet Engineering Ltd., Peterborough, ON, Canada. Manufactures nuclear decontamination systems.

Preferred Utilities Manufacturing Corp., 31-35 South St., Danbury, CT 06810. Manufacturer of equipment for nuclear power plant refueling.

Professional Protection Systems (PPS) Ltd, Sherbourne Drive, Tilbrook, Milton Keynes, Buckinghamshire, MK7 8HX, UK. Manufacturer of decontamination systems and shelters.

Siemens AG. Munich, Germany. Makes and services nuclear power plants, both pressurized water reactors and boiling water reactors.

Skoda JS a.s. Orlik 266, CZ-31606 Plzen, Czech Republic. Manufacturer of equipment for nuclear power plants and spent fuel casks.

Sogefibre - Valognes, Normandy, France. Manufacturer of fiber-reinforced concrete containers used for nuclear waste storage.

South African Nuclear Energy Corporation (NECSA). Pelindaba, South Africa. Processes nuclear power source material and operates the Vaalputs radioactive waste disposal facility.

Urenco Limited, 18 Oxford Road, Marlow, Buckinghamshire SL7 2NL, United Kingdom. Manufacturer of enriched uranium for the nuclear power industry worldwide.

TVEL Corp., 49 Kashirskoe shosse, Moscow 115409, Russia. One of the world's leading manufacturers of nuclear fuel. Serves 73 commercial (17% of global market) and 30 research reactors in 13 countries.

United States Enrichment Corp. (USEC Inc.). 6903 Rockledge Drive, Bethesda, Maryland 20817. Enriched uranium fuel for commercial nuclear power plants.

Urenco Group/Urenco Ltd., 18 Oxford Road, Marlow, Buckinghamshire SL7 2NL, UK. Operates uranium enrichment plants in Germany, The Netherlands and the UK and supplies nuclear power stations in about 15 countries.

URS Nuclear Center, Fort Mill, SC (Washington Group International Inc). Project management, engineering, construction, maintenance of nuclear power plants.

Vattenfall AB, Birger Jarlsgatan 33, SE-162 87 Stockholm, Sweden. Utility serving several nations in Northern Europe.

Westinghouse Electric Co., 3545 Whitehall Park Drive, Charlotte NC. Provides fuel, services, technology, plant design, and equipment for nuclear power plants. Westinghouse has contracts for four new reactors in China and six in South Korea. The firm has designed about half of the reactors in operation around the world.

A Suggested Organization Plan for Project New America

The project team should be a public/private entity insulated insofar as possible from the federal bureaucracy and political interference.

The responsibility for overall project management should be entrusted to a major U.S. engineering firm with a proven record of success in managing large, complex projects. The designated project manager should report directly to the President.

Under the project manager there should be directors for each element, such as:

- Director of nuclear energy industries
- Director of energy transmission industries
- Director of wind energy industries
- Director of solar energy industries
- Director of bio-mass energy industries
- Director of geothermal energy industries
- Director of water energy industries
- Director of electricity storage industries
- Director of new science industries

These directors should be professional executives with expertise in their areas of responsibility. None should be political appointees.

Priority in development of the management team should be given to those elements that are most important and that require the longest construction and start-up times. Thus, the first team elements to be organized would be the nuclear and transmission units. Their task would be to build new facilities that are operational within a few years – despite typical gestation periods as long as 20 years.

Other Books by McKinley Conway

(Most are available from www.amazon.com)

- Conway, McKinley. *Forecasting for Fame, Fortune and Frustration: Old and New Looks into the Future*. ISBN 0-910436-66-5. Norcross, Ga.: Conway Data Inc., 2008. 186 pp., 8½x11.
- Conway, McKinley. *Where The Action Is – Development Centers Today and Tomorrow*. ISBN 0910436657. Norcross, Ga.: Conway Data Inc., 2007. 335 pp., 8½x11.
- Conway, McKinley. *The Great Global Idea Race*. ISBN 0-910436-64-9. Norcross, Ga.: Conway Data Inc., 2007. 349 pp., 8½x11.
- Conway, McKinley and Lyne, Laura. *Global Super Projects: Mega Ventures Shaping our Future*. ISBN 0910436630. Norcross, Ga.: Conway Data Inc., 2006. 247 pp., 8½x11.
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About the Author

After graduation from Georgia Tech with two engineering degrees (aeronautical) and a pilot's license, McKinley Conway joined the staff of NACA/NASA. While a staff member at the HQ office in Washington in the early 1940s, he met Orville Wright, Jimmy Doolittle, Igor Sikorsky and other aviation legends.

After being commissioned in the Navy during World War II, Conway was assigned to the NASA Ames lab at Moffett Field, Calif., where he served as project engineer on tests of the Grumman F7-F, the first twin-engine fighter for carrier duty, and the Ryan FR-1, the first jet for carrier operations. He wrote the first textbook on *Principles of High Speed Flight*.

Conway left NACA/NASA to become director of the Southern Association of Science and Industry in Atlanta. SASI was a new organization of business executives, university professors, and public figures whose goal was to lift the Southern states from their status as a poverty-stricken agricultural area. The results of this work are highly visible today: The Southern states are now among the leaders in economic development, most of it in technology-related ventures. Moreover, the South's early program strategy has since been used with success by many regions around the world.

Conway later served as Chairman of the Georgia Science and Technology Commission, an agency set up to explore new economic development opportunities. It was the first such body in the nation. Many other ground-breaking ventures followed.

In the early 1960s Conway was a member of a five-man development mission sent to Southeast Asia by the U.S. Department of State. Later he was selected to direct the new AID/PEP (Agency for International Development/Private Enterprise Promotion) program in a dozen countries in Central and South America.

At home Conway, served as chairman of the DeKalb County Planning Commission while installing the first master plan for Atlanta's fastest-growing suburb. He also served as chairman of a metro government study panel set up by the state legislature. He was the plaintiff in a landmark federal court case that established the one-man, one-vote concept for the election of legislators.

Conway was elected to the Georgia Senate; during two terms there he introduced noteworthy legislation, including a "Sunshine" law to gain open meetings and records. He also co-authored the bill that created MARTA, the Metropolitan Atlanta Rapid Transit Authority.

A lifelong aircraft owner and pilot, Conway planned and developed the world's first total fly-in community, located at Spruce Creek, near Daytona Beach, Fla. Residents park their aircraft at their doors and enjoy unprecedented mobility. To explore development opportunities in remote areas, Conway logged more than 7,000 pilot-in-command hours that included pioneering flights across the Amazon basin and the Greenland ice cap.

Over the years Conway built his small communications business into a significant factor in development. His prestigious magazine, *Site Selection*, is the leader in the field. His electronic data service, *SiteNet*, attracts more than a million visitors a year from around the globe.

Conway has also been a founder of important professional bodies, including the International Development Research Council (IDRC), Industrial Asset Management Council (IAMC), and World Development Federation (WDF). He also was the founder of the World Development Hall of Fame, which recognizes individuals who create the world's most outstanding projects.

During the 1990s Conway chaired a series of Global Super Projects Conferences at Singapore, Honolulu, Barcelona, Paris, Osaka, Atlanta, Madrid and Jubail (Saudi Arabia). The result of this work can be seen today as true global systems are emerging, especially in energy and transport. Conway is proudest of the Great Global Highway concept that will eventually connect some 100 nations on five continents.

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